THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 41. Thursday, July 25, 1929. No. 675.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, or to the Publisher, as the case may be, of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2.

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (4 lines).

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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

MAY-OCTOBER.

North-East Coast Exhibition at Newcastle-on-Tyne.

JULY 16-27.

International Aero Exhibition at Olympia, London, W.

Technical Discussions.

Those who are in the habit of attending the technical sessions of the Institute of British Foundrymen appreciate that one of the outstanding features of these occasions is the good discussion that usually accompanies the presentation of Papers. The reason for this is probably that the majority of the Papers deal with practical points concerning which those present have definite practical experience and to the discussion of which they can therefore make some definite contribution. However, those who have followed the presentation of Papers to the various technical institutions during the past few years are becoming seriously concerned at the frequent failure of others of these bodies to discuss technical topics of what may be termed a controversial character.

It seems desirable to point out, therefore, at a period which may be regarded as a breathing-space between two sessions, that such Papers are commonly written in the full realisation of the fact that they are controversial, and with the deliberate intention of provoking discussion. The cost of preparing and presenting a Paper is considerable, and a large part of this cost may well be felt to be a waste if the hoped-for discussion is not forthcoming. It must, of course, be admitted that there are occasions when a Paper is best left undiscussed, because discussion would involve a measure of publicity that for one reason or another is felt to be undesirable. There are other occasions when it is difficult for men attached to commercial organisations to say what they feel or know on a given subject because to do so might not be entirely fair to the organisation employing them. But we have in mind Papers that would not be affected by such considerations. Rather are we thinking of Papers of a purely technical character which cannot be adequately criticised by more than a small number of persons, upon whom it then becomes in our view almost a duty to offer such criticism. In such cases, indeed, it may be assumed that the publication of the Paper is an indication that the author is anxious for such criticism, in order that the truth may be elucidated by the correlation of different people's experience on the subject. Moreover, in the cases that have been brought to our notice during the past few years, criticism would arise rather out of a man's academic knowledge than out of his commercial knowledge. It seems pertinent to add in this connection that an unfortunate tendency has lately manifested itself in the attitude adopted towards Papers on a given subject written by authors who are not admitted specialists on that subject. Surely this is one of the cases where the onlooker may well see more of the game, and surely too it is not a policy calculated to encourage recruits to the investigation of the subject concerned.

The German Foundrymen's Technical Association.

Owing to the incidence of the International Foundrymen's Congress, we feel that we have given insufficient prominence in our columns to the 19th Annual Meeting of the Verein Deutscher Giessereifachleute. This was held in Berlin, and 500 members and delegates took part. A report of the meeting will be published next week.

The Presidential Address, given by Dr. Humperdinck, presented a feature not encountered in any other of the home or foreign technical societies—that is, he made a definitely political speech. This he justified on the grounds that social and political ideas were penetrating and impairing industrial activities. He insisted that it was the duty of technical societies to stress the legitimate aims and positive character of the engineering industry. A thought he expressed, and one which most men of scientifically-trained mentalities will endorse, was that "the man in the street" is under the illusion that modern industry is so elastic and controlled with such erudition that it is capable of overcoming any and every burden imposed upon it, consequent upon present and future political and social conditions.

It is admitted that the limits of industrial economic production has not been reached. Dr. Humperdinck states that Germany is "frittering away millions and millions of marks lightheartedly on objects that have no true economic value," yet there is obviously a limit to the burdens which even the most efficient of industrial organisations can bear. Actually the greater the efficiency of the plant, the more delicate and sensitive to outside influences it becomes—in gaining efficiency it often loses elasticity and adaptability.

To our mind the most important thesis presented to the conference was one dealing with rationalisation. Its author, Oberingenieur G. Stern, advocates a reorientation of thought from the conception of measuring work done in terms of time expended, as measured with a stopwatch, to the idea of higher outputs for less expenditure of energy. Thus reference should be made not to what power the machine delivers in a given unit of time, but rather how many work units must be expended to perform the work required. Practical experiments with moulding machines not merely show the saving in human energy which can be effected, but there are indicated directions in which design can be improved.

This German meeting was certainly of a character vastly different from those held in America, France, Belgium and Britain. There seemed to be an undercurrent of propaganda in the meeting, designed to encourage the German foundryman to take more interest in extraneous affairs which only indirectly affect the technical conduct of his work.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

How We Stand To-day.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your leader, under the heading "How we stand to-day," you refer to the question of the gas-content control in cast iron. As this is a matter which has occupied the attention of our Research Department for some considerable time, we feel called upon to draw your attention to our activities in this direction.

With the object of minimising the trouble arising from the gas content of iron, we have devised a process by which our refined irons are agitated and treated to reduce the quantity of gas present. These *degasified* refined irons are now available to the industry.

We appreciate fully the technical difficulties in determining quantitively the effect of gas content. In fact, it is this difficulty that makes defects arising from this source so troublesome. Our experience with *degasified* refined irons so far leads us to believe that their use will prove of the utmost value in eliminating defects arising from these causes.—We are, yours, etc.,

Per pro BRADLEY & FOSTER, LIMITED,
G. T. LUNT, Director.

Darlaston Blast Furnaces,
Darlaston.

Institute of Metals.

As previously announced in our issue of June 6, the annual autumn meeting of the Institute of Metals is to be held in Düsseldorf from September 9 to 12.

The following communications are expected to be submitted at the meetings:—

"Studies on the Crystallisation of Gold from the Liquid State." C. O. BANNISTER.

"Idiomorphic Crystals of Cuprous Oxide in Copper." C. BLAZEY.

"Pinholes in Aluminium Alloy Castings." N. F. BUDGEN.

"A Dilatometric Study of Some Univariant Two-Phase Reactions." P. CHEVENARD, A. M. PORTEVIN and X. F. WACHÉ.

"The Relative Corrodibilities of Ferrous and Non-Ferrous Metals and Alloys. Part II.—The Results of Seven Years' Exposure to Air at Birmingham." J. NEWTON FRIEND.

"An Improved Differential Dilatometer." M. HAAS and D. UNO.

"Properties of Locomotive Firebox Stays and Plates." O. F. HUDSON, T. M. HERBERT, F. E. BALL and E. H. BUCKNALL.

"The Creep of 80:20 Nickel-Chromium Alloy at High Temperatures." A. GLYNNE LOBLEY.

"Methods of Research in Metallography." G. MASING.

"Reduction of Shrinkage Cavities and Vacuum Melting." W. J. P. ROHN.

"Some Methods of Research in Physical Metallurgy." W. ROSENHAIN.

"New Methods for Melting Non-Ferrous Metals in the Electric Furnace." M. TAMA.

"The Open-Air Corrosion and Surface Patina of Copper." W. H. J. VERNON and L. WHITBY.

"Effect of Temperature Attained in Overhead Electric Transmission Cables." A. VON ZEERLEDER and P. BOURGEOIS.

Full particulars are obtainable from the Secretary, Mr. G. Shaw Scott, of 36, Victoria Street, London, S.W.1.

John Wilkinson Medal.

The result of the recent examination held for the members of the junior section of the Institution of British Foundrymen, Lancashire Branch, to determine the winner of the Wilkinson Memorial Medal for 1929, has just been announced. This silver medal, to commemorate the work of the great ironmaster, who was known as the "Father of the Foundry Trade," is awarded annually by Mr. J. Thewlis Johnson, of the Bradford Ironworks, Manchester, and this year the examination took the form of three essays written upon a selection of foundry subjects. Amongst the 20 competitors, five only attained more than two-thirds of the total marks, and the winner was closely followed by the runner-up. First place has been awarded by the committee of examiners to Mr. F. L. Topham, who is a moulder with Messrs. Hick, Hargreaves, of Bolton. Mr. B. Haigh, of Metro-Vickers, Trafford Park, receives the President's book prize for second place, and the following competitors have been highly commended, with practically equal marks:—Mr. H. Harrison, National Gas Engine Company, Ashton; Mr. E. Sutcliffe, Messrs. Robinson's, Bolton; and Mr. A. Thompson, of Messrs. Beyer, Peacock & Company, Gorton. The senior branch council have congratulated the successful candidates upon their performance, and also Mr. Sutcliffe for having won the special prize presented by Mr. Jolley for the best short Paper presented by a junior member to the section during the past winter session. It is notable, also, that last year's winner of the Wilkinson Medal has this year been awarded the first of the Buchanan Medals to be sent to the junior section of the Lancashire Branch.

A New Cupola Tapped.

Mr. J. M. PRIMROSE, the manager, presided at a pleasant little ceremony performed in the Grangemouth Iron Company's Works at Camelon, Falkirk, on July 17, when the formal first tapping ceremony in connection with the new cupola, which was recently added to their plant, took place. Mr. Primrose said that while he was proud of the achievements of the past six years, that day seemed to him to be the climax, as he was of the opinion that it was not often nowadays that an additional cupola was introduced into any of the foundries in the district. The cupola, he said, had several novel features. It was designed to give a speedier melt with a lower consumption of coke. The firm, he continued, held orders which would keep some sections of the works fully employed for some months, while the prospects of the other sections were very much brighter than they had been for some considerable time.

On behalf of the firm, MR. JAMES RUSSELL, the works manager, made a presentation to Mrs. Primrose of a silver tea tray, suitably inscribed, as a souvenir of the occasion.

MR. J. C. FLETCHER, Consultant, British Cast Iron Research Association, the designer of the cupola, who also spoke, said that although the cupola was in a way experimental, he hoped, with the co-operation of the manager, it would turn out to be a great success.

At the close of the day each of the employees was handed an envelope containing a money gift.

Additional French Visitors.

The following is a further list of French delegates who were present at the conference in addition to those names given in our issue of June 27: Messieurs Vicaire, R. Ronceray, Marmoz, Rousseau, Flour, Baheux, Grossard and Gernelle-Danloy.

Random Shots.

I am in receipt of a letter from an esteemed Tyneside correspondent, in which he assures me that Captain Kettle, in travelling from Liverpool to the Tyne via Penrith, as I recently stated, was only displaying a degree of local knowledge that is rare in the characters of popular fiction. I am grateful for the information, and if I have reason to travel in that part of the world I shall most certainly remember that the tickets on the L.M.S. are prettier! But I should point out that "Marksman" is, after all, a busy soul; how, for instance, would *you* like the job of filling this column week by week, rain or shine? And as even Einstein has not yet discovered a way of making time elastic, I have had to relinquish the hope of conducting personal investigations into little details of this sort until some future date. However, I am never above acknowledging a mistake, you know, and I could wish that I made them oftener if they would always produce correspondence as entertaining as the letter I have referred to!

* * *

Rather curiously, I have encountered this week two other instances of the corrector corrected. The first concerns that most unpardonable error—a mistake in a detective story. Father Ronald Knox, that singularly brilliant inventor of mysterious crimes, has criticised the famous Sherlock Holmes for deciding that a pencil bearing the letters "NN" was a product of "Johann Faber"—casting doubt on the position of those letters at the end of the pencil. Investigation reveals, however, that the "NN" was on a chip *from* the pencil, not on the stump itself.

* * *

My second example is rather highbrow, so hold tight! A recent writer was poking fun at the German author of an English (so-called) handbook to opera—written, it may be said, with unlimited confidence, but with very limited English. Having pointed out a number of perfectly authentic errors, such as the phrase "happy coupled poirs," to express the conventional "pairing off" at the end of a play, and the use of "hearths" to express the seat of the emotions, the critic then proceeded to trounce the unfortunate German author for giving the new title of "What You Like" to an operatic form of Shakespeare's "As You Like It." And then referred to the character of Cesario. Now have you forgotten all you ever learnt? Or do you, too, remember that the play in which Cesario occurs is "Twelfth Night, or What You Will," so that "What You Like" wasn't such a bad shot after all?

* * *

At the risk of appearing obsessed by the topic of detective stories (and, as a matter of fact, since my orgy in the spring I have read very few) I must amplify my remarks about the problems of accuracy that beset the authors of these tales. A clever writer of detective stories recently gave a list of problems that he had to solve before satisfactorily completing a single story. For instance, what is the exact procedure when opening a London Underground station in the morning? How soon would rigor mortis set in in the case of a stout person murdered in a hot house? How long would you have to take arsenic before it appeared in your nail-paring? And so on . . . .

MARKSMAN.

Casting Temperature and Chill Cast Iron.

In the first part of an investigation* into the influence of the casting temperature upon the quality of chilled rolls, F. Busse deals with the observations he made in inspecting about four hundred rolls. The results can be summarised as follows:—(1) With irons low in silicon the depth of chill increases with the decreasing casting temperature; the reverse is the case with irons high in silicon. With medium silicon contents the depth of chill seems to be unaffected. (2) Grey spots on the surface could be detected most frequently in the upper part of the body; their appearance in the middle of the body was rare. These spots consisted of pearlite or mixed crystals intermingled with thin graphite flakes. (3) Blemishes extending from the surface into the interior to a depth of about 5 millimetres were always found with low-temperature irons (poured at 1,220 to 1,230 deg. C.); with rolls poured at 1,240 to 1,250 deg. C. these scars only occurred in the upper parts where the iron had cooled in pouring. (4) The same remarks apply to blisters found in the interior of the rolls. Under the microscope no graphite could be detected in the direct vicinity of the blisters, but segregations of sulphur and phosphorus, and non-metallic impurities. (5) Annular and longitudinal cracks were found with both the low- and the high-temperature irons. The longitudinal cracks occurred in the upper part and the lower part of the rolls, the annular cracks sometimes in the middle and more frequently in the upper part.

Point of Measurement	I	II	III	IV
Distance from the Chill Mould	20	30	40	50

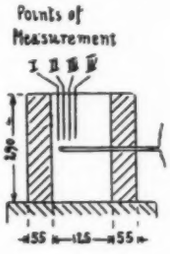

Fig 1.

In order to examine the influence of the casting temperature upon the structure, four series of experiments were made, each series being poured from the same ladle. The results are recorded in Table I. It is to be seen that the depth of the mottled area is greater with the samples poured at low temperature and with the low-silicon contents. The graphite, however, segregates here in nidæ, whereas with the samples poured at high temperature it is more equally distributed. Microscopic investigation showed that the samples poured at high temperature have a dendritic structure extending into the mottled area. The chilled area consists of cementite and mixed crystals, which look like troostite or sorbite. With the samples poured at low temperature the dendritic structure can only be seen in the vicinity of the chilled surface, and is followed by a globular structure. Here the mixed crystals of the chilled area consist of lamellar pearlite, and are frequently surrounded by a fine border of cementite. Ledeburite is only to be found in the case of the samples poured at low temperature, and it occurs nearer to the surface with a reduction of the pouring temperature. Towards the end of the chilled area the mixed crystals segregate in nidæ containing fine graphite lamellæ, the size of which increases with the increasing size of the nidæ.

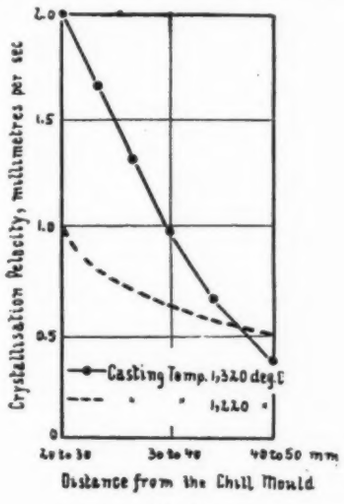

Fig. 2.

Further experiments were made to show the influence of the pouring temperature upon the cooling velocity. Cast iron was poured on a chill plate, and the cooling curves were taken at some distance from the plate. The difference of the pouring temperatures used was about 100 deg. C. It was found that the cooling velocity is, in the first minutes, greater with the samples poured at the higher temperature. After five to ten minutes the reverse is the case; then the samples poured at the lower temperature cool more rapidly, and temperatures of 700 deg. C. and below are sooner reached by them.

In further experiments, the speed of crystallisation was measured. Cast iron was poured into an annular chill mould, and the beginning of the solidification was determined with the means of thermo-couples at different distances from the interior surface of the mould. The experimental arrangement is illustrated in Fig. 1 (measures given in millimetres). The casting temperatures were 1,320 and 1,220 deg. C. respectively. The mould was heated to about 90 deg. C. The composition of the iron used was as follows: Carbon 3.35 to 3.42, silicon 2.1 to 2.2, manganese 0.7 to 0.78, sulphur 0.11 to 0.12, and phosphorus 0.6 to 0.7 per cent. The values of the speed of crystallisation calculated from the experimental data are illustrated in Fig. 2. Here the same result is obtained as with the cooling velocity: in the first minutes the crystallisation velocity of the samples poured at the higher temperature is greater than that of the low-temperature samples; later on the reverse is the case.

From the results of his experiments the author deduced a diagram, which illustrates the influence of the casting temperature (between 1,220 and 1,320 deg. C.) upon the structure of chilled iron. This diagram is reproduced in Fig. 3. Thereby it is assumed that the chemical composition of the iron is such that the depth of chill is always the same (20 millimetres) irrespective of the degree of the casting temperature. (This is the case with series II and III, Table I.) The area above the line W is that of the white iron, between the two lines W and M the mottled iron occurs, and below the line M, grey iron is found. Therefore the crystallisation speeds y_w and y_m represent the minimum velocities for the formation of the white and the mottled iron. From Fig. 3 it can be seen that, for the iron in question, the depth of the mottled area is 5 millimetres with the high casting temperature, and 10 mm. with the low casting temperature. The velocities y_w and y_m depend from the composition of the iron, especially the carbon and silicon contents. When the silicon increases the minimum velocities increase too, and the two lines W and M must be relegated to a higher position; in this case it can be seen from the diagram that the depth of chill is greater with high casting temperatures. When the silicon content decreases the two lines must be lowered somewhat, and thus the depth of chill becomes greater with lowered casting temperature. The depth of the mottled area continually increases with the decreasing silicon content, and is always greater with low casting temperatures. The critical silicon content with which the same depth of chill is associated with both low and high casting temperature is between 0.6 and 0.9 per cent.

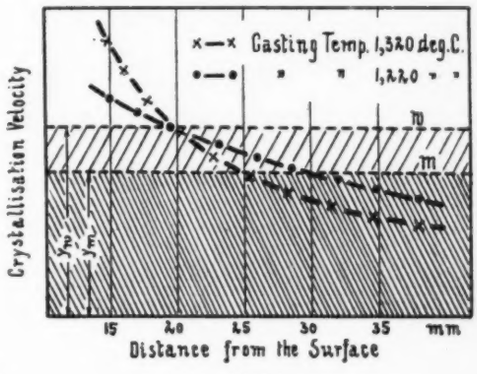

Fig. 3.

For practical working the author recommends to pour at a fairly high temperature in order to get a clean surface free from blisters; but the casting temperature must not be so high (above 1,300 deg. C.) as to produce a plain dendritic structure, which is always associated with poor mechanical properties.

TABLE I.

Series No.	C	Si	Mn	S	P	Sample.	Pouring Temperature.	Depth of Chilled area.	Depth of Mottled area.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	No.	Deg. C.	Mm.	Mm.
I	3.60	0.86	0.58	0.098	0.734	1	1,310	13	10
						2	1,220	10	15 blisters
II	3.61	0.71	0.35	0.104	0.39	1	1,320	23	20
						2	1,260	23	22
III	3.60	0.72	0.38	0.101	0.32	1	1,320	25	20
						2	1,270	24	22
						3	1,230	24	25 blisters
IV	3.58	0.89	0.44	0.067	0.28	1	1,290	10	6
						2	1,220	8	12 blisters

* "Die Giesserei," 1929, No. 8, pp. 169–79.

Some Theories of Graphitisation—Part II.

By H. A. Schwartz, M.E.

The occurrence of the first infinitely small graphite nodule in a mass of solid iron theoretically requires an infinite amount of work per unit volume to expand the iron, and hence the beginning of graphitisation in a perfectly homogeneous metal phase is theoretically impossible. That graphitisation can begin at all, in practice, is probably due entirely to the non-homogeneity of the metal.

If there exist in the solid metal any inclusions of crystal habit such that graphite can crystallise upon them, graphitisation is accelerated in proportion to the number and volume of these inclusions. Graphite itself, persisting from flakes not dissolved in the molten condition, furnishes the best possible "seeding" or inoculation, and the work of Piwowarski[25] on the effect of superheating molten grey cast iron points to the possibility of such residual graphite. Failing any such inclusions the existence of fields of stress in iron may serve as nuclei for graphite crystallisation. In all white cast-iron there are present at least two solid phases, cementite and either austenite or ferrit. There will be present at the boundary of the two phases surface tension phenomena which tend to separate these boundaries where sharp angles exist, and thus produce internal tensile stresses favourable to the crystallising out of graphite. And, indeed, it seems likely that the first occurrence of graphite is generally at the surface of cementite and certainly never within that constituent. This consideration also contains, perhaps, the difficulty of starting graphitisation in material containing much less than 2 per cent. carbon which at any temperature (above A_1) at which graphitisation might be fairly rapid are composed of a single solid phase.

Effect of the Decomposition of Cementite.

The mechanical work which must be done in order that cementite may decompose in solid iron introduces another very interesting subject upon which we can as yet but speculate. The decomposition of cementite is accompanied by the liberation of a given amount of energy, a portion of which is expended in expanding the metal in which the graphite grows. In addition to the relation just pointed out between the size of graphite particles and the energy required for expansion, there is another variable of importance.

It is well known that all the metals, at high temperatures, behave like very viscous liquids. They continue to flow at a constant rate proportional to the force applied. If an attempt be made, therefore, to accelerate graphitisation, we increase the rate at which we require the iron to stretch, hence the stress, and consequently the work required to produce a given increase in volume at a given temperature. But this work is done only by the liberation of energy from a given amount of cementite, and hence cannot exceed a definite amount. This limitation may prevent graphitisation proceeding more rapidly than some fixed maximum value, for any given size of graphite nodules. We still lack many of the data requisite for giving the relation a precise mathematical form.

The number of centres of crystallisation, or carbon nuclei, is determined by laws which are as yet but incompletely understood. The considerations already advanced point to a distinct relation between the fineness of distribution of cementite and the number of carbon nodules formed, per unit volume.

It is also generally true that at high temperatures more centres of crystallisation exist in a given metal than at low temperatures.[26]

Reference has already been made to the fact that in ordinary white cast-iron there is little increase in number of nodules with time, in other words, all the potential centres develop at once. In the case of nickel alloys, however, the reverse is approximately true, and nodules increase in number but do not grow much in size, reaching their final dimensions very quickly. Also there is but little growth of large nodules at the expense of small ones, as required by theory, on holding metal at constant, elevated temperature. A lowering of the temperature to a new constant value, however, frequently involves an increase in size, and decrease in number of nodules.

Influence of Gas Reactions.

Reference has already been made to the work of Hayes and associates showing that graphitisation is accelerated by increase of pressure if occurring in a CO-CO_2 atmosphere. Their conclusion is very largely accomplished by the sum of the two reactions

$$Fe_3C + CO_2 = 3\,Fe + 2\,CO$$

and

$$2\,CO = C + CO_2$$

the atom thus migrating in the gas phase and not at all through the metallic-iron lattice.

The relation between furnace atmosphere and graphitisation has been studied in the author's laboratory, and some rather interesting results observed which confirm the conclusion that such reactions play a part in the mechanism of graphitisation.

Thus in neutral gases such as nitrogen and argon, as well as *in vacuo*, graphitisation is possible but rather slow. In CO_2-CO it is accelerated, but if either constituent is continuously removed chemically, the reaction is about as slow as in neutral gas.

Two reactions

$$Fe_3C + 2\,H_2 = 3\,Fe + CH_4$$

and

$$CH_4 = C + 2\,H_2$$

could and do cause graphitisation as in the case of CO-CO_2 mixtures. In pure hydrogen, however, the reaction is not rapid though more so in CH_4. In acetylene it is exceedingly slow, probably because that gas decomposes directly into carbon and hydrogen at the temperatures involved so that one is working practically in hydrogen. Moist gases are usually more active than dry ones, which suggests that the reaction products of the oxygen of steam are of importance.

It is very well in this connection to consider also that gas reactions may be of considerable importance in the study of graphitisation. If at a given temperature and pressure, CO_2 can burn the carbon of cementite and CO decompose into CO_2 and carbon, then at the same temperature and pressure Fe_3C must also dissociate into its elements, and C as Fe_3C must be more soluble than as the element. If this were not so we could create or destroy energy by first forming Fe_3C by one reaction and then destroying it in the same environment by another.

Also it is necessary that the vapour pressure of carbon from a saturated solid solution in iron must be identical with that of the element at the same temperature or else if the two were in the same enclosure carbon would pass from the phase of highest vapour pressure to the other, and the solution would change concentration in contact with the solute, and hence not be originally saturated. The vapour pressure of carbon from Fe_3C and from solid solutions saturated with respect to carbon must be similarly identical, and if Fe_3C be metastable, the vapour pressure of carbon from the compound must be greater than that from the element. These matters are self-evident to the physical chemist, but are not always recognised in America by the metallurgist. A clear comprehension of the matter will, however, prevent vain experiments in attempting the reversal of a reaction by purely environmental changes.

If, for example, it can be once clearly shown that Fe_3C is metastable, *i.e.*, desirous of dissociating, at all temperatures below the solidus, then it is impossible that the line marking the solubility of carbon in the equilibrium diagram for the stable system can ever fall to the right of the corresponding line in the metastable diagram, a point worthy of consideration by those proposing modifications of the present equilibrium diagrams.

Influence of Alloys.

Also any alloying element which renders Fe_3C stable, as distinguished from retarding graphitisation rate, must, *ipso facto*, increase the solubility of carbon more rapidly than that of cementite, and must also alter the gas equilibria in such a manner that carbon is more combustible as the element than as the compound present. In all these matters we must clearly distinguish between the direction of the graphitising reaction and its velocity. Thermodynamics deals only with the former.

We may now turn to the application of the scientific principles so far discussed to the practice of the iron foundrymen. Quite obviously the grey-iron foundryman wishes to promote a certain definite degree of graphitisation during cooling in the mould and the malleable foundryman wishes to produce no primary, but complete secondary graphitisation.

Since for a given character of graphite flake the physical properties are predominantly determined by graphite content, both will first strive to control carbon concentration in the liquid metal. The grey-iron foundryman, confining himself largely to cupola melting, is here at a disadvantage, for he can produce only a concentration which is near the solubility of carbon in liquid iron at his metal temperature, and hence also is unavoidably confronted with a carbon content increasing with increased melting temperature. For this reason, in America, the cupola has been abandoned as a melting furnace for high-quality malleable and melting is conducted in some manner in which the liquid metal is not kept in contact with an excess of carbon. It is then possible to exercise fairly close control over the desired carbon content by suitable selection of melting stock.

Limit of Graphitisation Range.

The acceleration of graphitisation with increasing temperature causes the reaction to be so rapid above, say, 1,000 deg. C., that during cooling in the mould to this temperature much graphite may separate, especially if the composition of metal be favourable and the cooling rate slow, as in large castings. The grey-iron foundryman thus works with rather high silicon metal and the malleable foundryman with rather low. Except in the case of very large sections, cooling rates are such that no great amount of graphitisation ever occurs at temperatures very much below 1,000 deg. C. The grey-iron foundryman, therefore, cannot produce a casting of lower combined carbon than the saturation point of his iron for carbon at about 1,000 deg. C. An increase in silicon content, decreasing carbon solubility, will thus decrease the combined carbon in grey iron independently of its effect on graphitising rates.

The malleable foundryman will wish to graphitise his graphite-free castings completely and as rapidly as possible, but will desire to keep free carbon in reasonably nodular form. He will thus first choose a silicon content as high

(*Continued on page 60.*)

25 "Ueber den Einflusz der Temperatur auf die Graphitbildung im Rohund Gusseisen," Stahl und Eisen, Vol. 45, 1925, p. 1455.

26 "Relation of Temperature to Form and Character of Graphite Particles in the Graphitisation of White Cast Iron," Transactions American Foundrymen's Association, Vol. XXX, pp. 395–410.

XUM

The Critical Examination of Steel Castings.

By G. F. Gillott, B.Met.

(Communication from the Research Department, Woolwich.)

(Continued from page 40.)

The annealed casting may show two distinct types of microstructure, one which may be termed the normal structure of pearlite grains embedded in a ground mass of ferrite (Figs. 13 and 15), and the other a pearlite network surrounding the aggregates of small ferrite grains (Figs. 17 and 18). Piwowarsky* attributes the network structure to the influence of aluminium or some other element such as vanadium, added to the molten steel as a deoxidiser, and the present author has only observed this network structure well developed in electric-furnace steels to which aluminium has probably been added in all cases. Fig. 17 also shows extensive decarburisation round blowholes caused by steam from a green-sand mould which blew through the plastic metal. The blowholes appear as dark areas in the decarburised region. The reverse effect is shown in Fig. 19, which illustrates surface-carburisation of a steel casting occurring when the very hot metal lay in contact with a carbonaceous mould-dressing. Rather deep surface carburisation has later occurred, probably owing to the access of air to the annealing furnace. Such decarburisation by mould "washes" may conceivably be one cause of difficulty in machining the surface skin of a casting.

The use of microscopical examination as a routine test and the keeping of systematic records of the microstructure of the test-bars, along with the analytical and mechanical data they provide, will tend to throw light on such points as have been mentioned and lead to greater uniformity and improved quality of the product.

For purposes of investigation it is usual to complete a macroscopical examination before selecting small specimens for polishing, etching and microscopical examination from the positions which show promise of giving most information. In illustrating some of the structures so encountered, it will be convenient to revert to the explanation of the indications of the radiographs and of the macrosections.

* Stahl und Eisen, 1928, *48*, 1665.

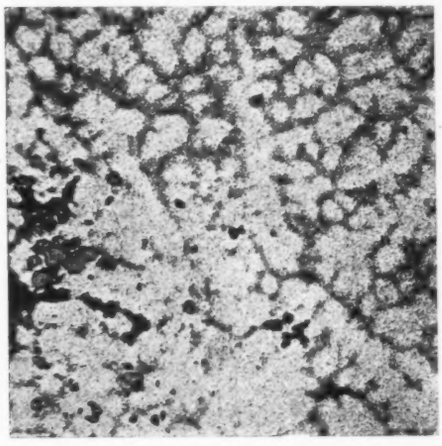

FIG. 17.—MICROSTRUCTURE OF CASTING, SHOWING DECARBURISATION, BLOWHOLES AND NETWORK STRUCTURE. × 25.

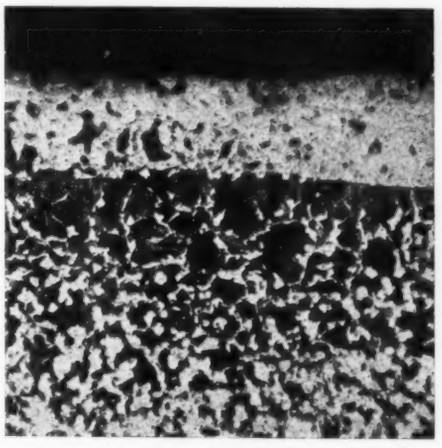

FIG. 19.—PHOTOMICROGRAPH, SHOWING SURFACE CARBURISATION AND DECARBURISED LAYER. × 25.

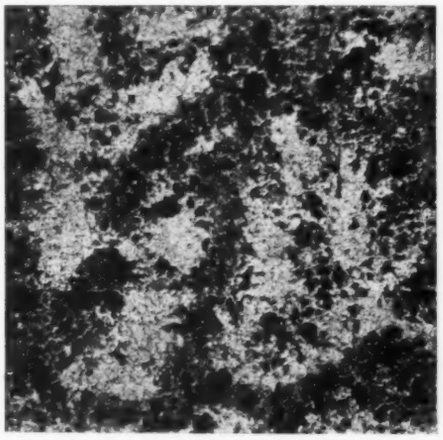

FIG. 18.—PHOTOMICROGRAPH, SHOWING PEARLITE NETWORK. ×100.

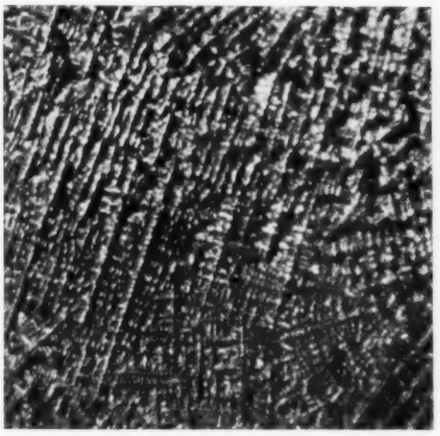

FIG. 20.—PHOTOGRAPH, SHOWING DENDRITES IN RELIEF ON SURFACE OF CAVITY. × 10.

The Occurrence of V-segregates.

During the last stages of freezing of an ingot, as sinking of the liquid steel occurs to compensate for contraction, the segregates in the adjacent viscous material are drawn down with it, and the sagging effect gives rise to the V-shaped segregates characteristic of the axial region of an ingot. In a casting the metal rising steadily in the mould begins to solidify at the mould surfaces, forming dendritic crystals, which grow at right-angles to the surface of the mould. As the dendritic growth proceeds, the temperature of the metal continues to fall until the conditions are such that free growth of crystals can take place from nuclei formed in the remaining liquid. The solidification of this liquid will not be complete until after the mould has been filled, and will be accompanied by a considerable movement to compensate for contraction. The V-segregates indicate movement of the solidifying metal towards the portion of the casting where solidification is first completed. Such V-segregates are shown in the sulphur prints, Figs. 6 and 7, and in the macroprints, Figs. 9 and 10. In other words, feeding occurs in the direction of the point of the V, and any cavities present below the V indicate that feeding from this direction cannot be adequate, and that it is desirable to provide additional feeding at another position.

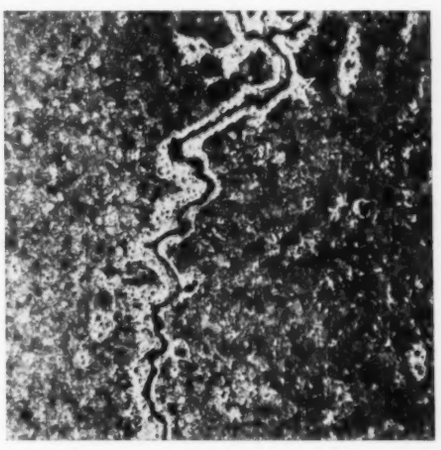

FIG. 21.—PHOTOMICROGRAPH OF COPPER-ETCHED SPECIMEN, WITH CRACK IN SEGREGATED REGION.

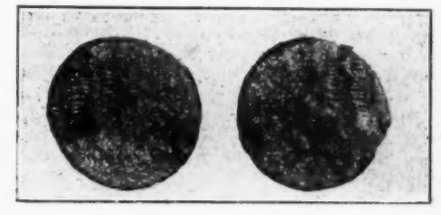

FIG. 22.—FRACTURED TENSILE TEST PIECE, WITH FLAW SHOWING OUTLINE OF DENDRITES.

Contraction Cavities and Blowholes.

Although the word "blowhole" is frequently used as a general term to include all kinds of cavities in steel castings, such use is quite unjustified. Voids are of two kinds at least. Blowholes, excepting the small pinholes seen in oxidised metal, are rarely due to the evolution of gases from the metal, since the steel supplied for foundry purposes is usually well deoxidised. Blowholes due to gases evolved by the metal are usually bright on their inner surface. The more usual cause of blowholes is steam, air and organic gases given off by the sand of the mould or core in contact with the hot metal, and unable

to get away through the sand, either owing to inefficient venting or to unforeseen trapping by some intricate part of the casting. Patching of the mould with damp sand just before casting is another cause of this type of blowhole. Such blowholes usually exhibit an oxidised scaly inner surface, as the gases involved are of an oxidising character. This type of defect may be accompanied by the decarburisation already mentioned in connection with Fig. 17.

More serious than blowholes, and usually more difficult to avoid, are contraction cavities. These arise from the same causes as piping in steel ingots, namely, the liquid shrinkage of the metal, together with the large contraction on freezing. Since these cavities occur generally in the portions of the casting which solidify last, they are frequently associated with the low melting-point segregates of the steel, and the surrounding segregated area is frequently porous. Such a contraction cavity in an acid open-hearth casting is illustrated by the radiograph Fig. 1. On cutting into this cavity the whole of the inner surface was bright with the exception of a few adhering particles of greenish slag. The upper surface was fairly smooth, but the lower surface, being covered until a later stage of cooling with a pool of still-liquid metal, allowed free growth of the dendrites to proceed until the liquid was exhausted. The photograph (Fig. 20) of the floor of the cavity shows the dendrites in relief. On the bottom of the cavity were also several small shots of lower melting-point material squeezed out from between the growing dendrites by contractional movements. The macrosection (Fig. 8) was cut from the wall of a long hydraulic-cylinder cast in a horizontal position. Near one end, three shrinkage-cavities appear, partly filled in their lower part with segregates which form a horizontal row along the middle of the section.

The characteristics of these contraction cavities indicate the desirability of casting where possible with the heavier sections uppermost and of providing large feeding-heads over such sections.

Interdendritic Weakness.

Cracks such as are revealed by X-ray examination (Figs. 2 and 3) and shown in the macrosection (Fig. 8) are frequently localised in the interdendritic segregation. These regions would remain fluid and plastic longer than the surrounding materials and would form surfaces of weakness at high temperatures, along which cracking would be likely to occur under the influence of tensile stresses set up by the resistance of the sand to the contracting casting and by unequal sections in the casting itself. Fig. 21 is a photomicrograph of the region round one of these cracks, polished and etched with Stead's copper-reagent. It will be seen that the copper has not deposited on the material immediately round the crack, indicating that this contains segregated impurities which are extremely weak at high temperatures. That actual interdendritic separation may be present in the casting is shown by the fracture of the tensile test-piece (Fig. 22), in which a flaw showed the contours of the dendritic surfaces. In this way arises the serious defect known as "hot-tear" or "pull." The recent work of Körber and Schitzkowski* has confirmed that these cracks occur during cooling down of the casting after freezing, in the region of 1,350 deg C. If the stresses which give rise to hot-tearing are to be minimised, the sand of the mould must be loosened before the casting has cooled to this range, that is, within 3 to 5 minutes of the finish of casting. Since the hot-tears arise in the segregated material, considerable improvement is obtained by using a purer metal. This explains the relative freedom from such cracks of electric-furnace refined-steel as compared with converter metal. In particular, the steel should be as free as possible from sulphur, phosphorus, and oxygen, which are the chief offenders.

* Stahl und Eisen, 1928, *48*, 129 and 172; F.T.J., 1928, *39*, 47.

Further Explanations of the Radiographs.

Reverting to Fig 1, the cavity has already been considered. The edges of a long chaplet are outlined by faint horizontal parallel lines of less density, indicating slight discontinuity. The two stems of the chaplet are outlined by rough dark circles, caused by the coating on the chaplet of some heavy metal (probably tin or lead-zinc) which is more opaque to X-rays than steel. The scattered dark spots along the chaplet probably arise from the same cause. The dark shadow at one end is due to a heavier section of the casting. The white spots are small voids, possibly blowholes, and the black square marked with the letter "C" is a lead index-mark attached to the casting for identification purposes. The radiograph (Fig. 2) shows a network of fine transverse cracks, which caused copious leakage from the walls of a hydraulic cylinder, although the defects were not noticeable on a superficial inspection. Fig. 3 shows circumferential cracks or hot-tears near a change of section in the same casting. Fig. 4 is a radiograph illustrating a possible danger in the use of temporary brackets or fins to strengthen a change of section with the object of avoiding "pulls." This has had the effect of localising cracking at the end of the brackets, which were ended-off too abruptly. A similar type of crack can be caused by a heavy chill, applied with the object of improving the soundness of thicker sections, if the chill is not tapered off sufficiently at the edges. Fig. 8 shows a macro-section through the transverse cracks similar to those shown in the radiograph, Fig. 3, and just to the right of the crack can be seen several bright streaky segregates which form likely paths for the formation of cracks at high temperatures.

The "Chill" Effect.

A peculiar surface effect is often noticed in sections of steel castings, illustrated in the sulphur-print, Fig. 7, and in the ink-prints, Figs. 10 and 11, as a layer of material differing in macrostructure from the interior of the casting. This layer is often separated from the interior by a layer of purer material, shown in the ink-macroprints as a white line. In Fig. 10 this line separates the V-segregated interior region from the surface layer. In Fig. 11 the line is crossed by columnar dendrites. Although this "layer" effect is probably connected with the slight chilling-action of the sand-mould, no complete explanation has yet been offered to account for it.

Conclusion.

Some features of the structure of steel castings have been discussed, but it is not considered to be within the scope of this Paper to indicate or suggest radical modifications of the methods of casting designed to overcome some of the defects which have been illustrated. Although steel-founders have devoted much time and study to investigating the problem of securing the best-possible castings, it remains an ever unsolved problem in view of the continually more exacting demands of the engineer. The only hope of continuing to meet these demands is by intelligent application of the results of critical examination carried out on lines such as those suggested in the present Paper, coupled with practical observations made in the foundry.

MESSRS. HERDMAN & THORNTON, engineering agents, have removed from 72, Osborne Road to Neville Chambers, Newcastle-on-Tyne.

THE STAVELEY COAL AND IRON COMPANY, LIMITED, Chesterfield, have dismantled the five furnaces at their New Works. The furnaces dismantled are Nos. 1, 2, 7, 8 and 9. Nos. 1 and 2 were originally built about 1844 and rebuilt in 1888. Nos. 7, 8 and 9 were also built about 1888. They were all about 45 ft. high, and were provided with old-type stoves. They had been out of blast for a number of years. The four furnaces at the Staveley Coal and Iron Company's Devonshire Works are all in blast.

Some Theories of Graphitisation—Part II.

(*Continued from page 58.*)

as possible without producing primary graphitisation. He will heat the casting as rapidly as possible to the highest temperature convenient which will not render the casting so plastic that flakes of graphite may grow. About 900 to 925 deg. C. is probably the upper limit from this viewpoint. He will keep his castings at this temperature until all cementite has been destroyed by dissolving in iron and crystallising as carbon. He will then cool the castings to below the A_1 point, where carbon becomes insoluble and keep them at a constant or slowly decreasing temperature below this point and high enough to permit fairly rapid graphitisation till the remainder of the carbon has all crystallised out and will thereafter cool as rapidly as convenient.

It is well known that quick cooling from a temperature a little below A_1, after completion of graphitisation is advantageous. Marshall,[27] has emphasised this point.

It is fortunately desirable to carry on the reaction in an atmosphere of CO-CO_2. This atmosphere not only helps graphitisation rate, but also can be caused to protect the casting from surface oxidation. Contamination of the desired atmosphere can best be prevented by packing castings in iron containers in a refractory powder of such character as to be in equilibrium with a gas phase richer in CO than that in equilibrium with the lowest oxide of iron (Schenk's Wüstite). The ferrous silicates are convenient for this purpose and the use of the higher iron oxides, hematite, for instance, is carefully avoided.

There is no need of decarburisation, as in the old process of Reaumur, for the black interior portion has the properties desired by the consumer, especially machineability, to a greater extent than does the surface. Were a packing available which prevented decarburisation its use would be desirable if unattended by any other difficulty.

The use of higher iron oxides as packing, coats the casting with a skin of oxide, which is occasionally reduced to metallic iron by a change of atmosphere and then becomes a thin detachable sheet of nearly pure iron which is very undesirable on commercial castings. Also atmospheres which will contaminate the metallic portion of a casting with oxygen are a possible cause of difficultly machineable, pearlitic, or steely rims, sometimes called "picture frames" in America. These possibly arise from the probable circumstances that Fe_3C is stable and not metastable towards iron oxides and carbon.

The writer is fully conscious that he has not, in this communication, dealt conclusively with any portion of the subject matter, nor exhaustively with the problem as a whole. The purpose has been to compress into a paper of reasonable length a summary of some of the principal factors requiring consideration in any real scientific study of the phenomena of graphitisation. It has seemed inexpedient to enter upon manufacturing methods, in view of the necessarily great differences in operating conditions in France and the United States. Apologies are further due for the fact that the references are drawn largely from other than French sources. An American student naturally is most familiar with the technical literature of his own country, and next with other publications, English and Japanese, in his own language. It happens that the present writer reads German more readily than French, hence he may have unintentionally neglected much work by French scientists to which reference should have have been made.

[27] "The Embrittlement of Malleable Cast Iron Resulting from Heat Treatment," United States Bureau of Standards Technical Paper, No. 245.

The Practical Application of Nickel in Cast Iron.*

By Arthur B. Everest, Ph.D.

Introduction.

The use of nickel in cast iron is by no means new; in fact, it is surprising to find that the possible improvement of castings by the use of nickel was recognised as long ago as in 1799, when a patent was taken out by Hickling, covering the use of nickel in hollow vessels of cast iron. Since that date many other patents have been taken out, and there are records in numerous publications of recognition of the fact that the introduction of nickel produces beneficial results in ordinary cast iron. It has been of great interest to find that at least one well-known firm of engine manufacturers has used nickel in its castings for a number of years, and a Midland firm is known to have incorporated nickel up to 3 per cent. in pistons, valve-liners and piston-rings for ammonia compressors regularly since the year 1896.

The development of alloy cast iron, however, has only recently come extensively under the notice of engineers, and to-day the demand for higher quality material is becoming ever more insistent in the course of engineering progress. The demand for improved cast iron is an urgent one, for, although cast iron for some time has been considered the Cinderella amongst commercial metals, nevertheless engineers are now realising that it possesses some valuable and irreplaceable properties, other than its low initial cost, which render it superior in many applications to its more highly-refined and expensive competitors. These characteristic properties include ease of melting and casting into intricate forms, good machining and wearing properties, as well as certain useful electric and magnetic qualities. It is to make the most of these various properties that progressive engineers and foundrymen are now turning their attention to a consideration of the improvements which are obtainable in cast iron by various methods at an economic cost. In this connection the employment of alloy cast iron is being intensively studied, and the results of this development work are already to be seen in the rapidly growing interest in the use of such metals as nickel in the cast-iron foundry. The choice of nickel as an alloy element has been fully justified on physical and chemical grounds,[1] [2] as well as by the results of practical experience.

A great deal of extensive research, both at home and abroad, has recently established the theoretical and fundamental influence of nickel in cast iron of various forms, and the results of such work are, no doubt, too well known to require repetition here; they were summarised recently in a number of Papers, two of which, under the broad title of "Alloy Cast Irons," were delivered before the Institute of British Foundrymen.[3] [4] Foundrymen and engineers to-day are now keenly interested in the application of these results in industry, and the object of this Paper is to review briefly the current situation in the development of the alloy irons containing nickel and to describe some of the results now being obtained.

Application of Nickel in Cast Iron.

Clearly the successful application of any alloying element in a basic material such as cast iron must depend on obtaining an improvement consistent with economy in the production or service of the material. Under these conditions the added cost may be met either by the economies effected in production or by the enhanced market value of the special material on account of its improved properties, or clearly by a combination of these two. In the case of nickel there is already apparent a growing demand for the alloyed iron, which is based on the improved qualities which this material is daily being demonstrated to possess, and it is now thought only to be a matter of a short time before engineers will be specifying such special irons in their castings, and recognising the need for paying an adequate price for them. With the recognition of the superior qualities obtainable in cast iron by the use of alloy additions, it seems probable that an improved standard of prices for all classes of high-quality engineering castings will be obtained, which will benefit the foundry industry as a whole.

DR. A. B. EVEREST.

The successful application of nickel in the foundry is due largely to the fact that the benefits derived from its use are obtained generally with a comparatively small addition, and in most of the applications to which reference is made in this Paper the nickel content in the final product is of the order only of 1 per cent.

The benefits derived from the alloy addition may usefully be divided into two groups, those which assist in the production and manipulation of castings in the works and those which result in improved service from the cast part. The first of these groups may be sub-divided into improvements which are seen in the foundry and those which are seen in the machine shop. Knowledge of the first of these groups must necessarily be greater at the present time than is that of the second, for it requires the passage of considerable periods of time to obtain complete service records of engineering materials, and little value can be attached to accelerated service tests, such as wear and corrosion tests; results of service tests are already coming to hand, however, and a growing demand for the alloy iron, based on the improved service given, is now making itself felt.

Advantages of using Nickel in the Foundry.

The basis of the application of nickel in cast iron is undoubtedly its equalising action on the structure of thick and thin sections of a casting. It has been established that, whereas an ordinary iron cast in a ¼-in. section will show a white chilled structure, at the same time this iron will be open and soft in a heavier section of 1 in. or more; nevertheless, in the corresponding nickel-iron, with a content generally of 1 per cent. of nickel, the tendency to chilling is eliminated, so that the thin section is grey and machinable and at the same time the heavier section is appreciably hardened owing particularly to the action of nickel on the matrix of the iron.[5] Fig. 1 gives a typical example of the hardness figures obtained in normal and nickel-iron castings, and illustrates well the equalising effects mentioned. Records show that in some cases a hardness difference of about 200 Brinell between the ¼-in. and 1-in. section of a casting may be reduced to about 20 points in a casting suitably alloyed with nickel, and at the same time the iron is very appreciably hardened and strengthened in the heavier sections.

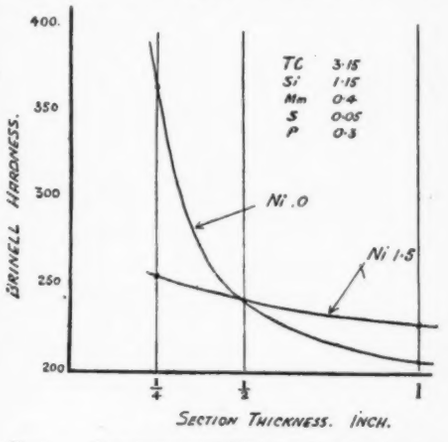

FIG. 1.—INFLUENCE OF NICKEL IN EQUALISING HARDNESS AND STRUCTURE.

Uniformity of Product.

The practical result of this equalisation is that the nickel-iron shows a much greater latitude as compared with the ordinary iron, so that uniform structure may be obtained over a wide range of section-thickness. This has a very important application in the foundry in enabling certain difficult castings to be made satisfactorily, in which high hardness and strength is required in heavy sections; or sections which cool slowly owing to casting design, whilst the metal quality is determined by the machinability of some thin section on the outside of the casting. As an example, reference should be made to the often-quoted case of motor-cylinder blocks, where the hardness and closeness of the cylinder bores and of the valve seats are of paramount importance in obtaining maximum wear, and yet the quality of iron is often determined by the machining requirements on some small water-exit boss situated in the middle of a thin-section water-jacket.[6] This particular application of nickel will, however, receive further attention under the heading of "The Properties of Nickel Cast Iron."

It is in this connection especially that great improvements in strength and properties can be demonstrated in cast iron by the use of nickel. Disappointment is sometimes expressed at the

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2 ALLOY CAST IRON. A. B. Everest. "Foundry Trade Journal," January 17, 1929, p. 45.

3 ALLOY CAST IRON. D. Hanson. "Foundry Trade Journal," November 1, 1928, p. 319; November 8, 1928, p. 337.

4 POTENTIALITIES OF ALLOY CAST IRONS. "Foundry Trade Journal," February 7, 1929, p. 107.

5 INFLUENCE OF NICKEL CHROMIUM ON CAST IRON. A. B. Everest and D. Hanson. "Foundry Trade Journal," January 3, 1929, p. 5.

6 NICKEL IN CAST IRON. A. B. Everest. "Foundry Trade Journal," April 12, 1928, p. 255; April 19, 1928, p. 274.

* A Paper presented to the recent International Foundrymen's Congress.

meagre improvements which may be shown by test-bar results, but, as the author has already pointed out,[4] the separately-cast test-bar is not capable of measuring the strength of vital internal portions of a casting, and it is by using an iron such as a nickel cast iron which possesses a greater uniformity in structure from section to section and a greater latitude, that appreciable improvement in these vital sections is obtainable, whilst uniform machinability is maintained.

For thin section, but somewhat intricate, castings (required to be tough and perhaps machined locally), such, for example, as manifolds for internal-combustion engines and switch covers, great uniformity of production is being obtained by the regular incorporation of a small percentage of nickel in the iron. A similar application is found in the production of small pistons, when perhaps five or six pistons are cast from one runner. Any tendency for the piston farthest from the pouring end of the runner to show chill and hard spots may be successfully combated by the use of nickel in the iron.

In virtue of the enhanced latitude of the alloy iron, a much greater uniformity of product may be obtained. This is especially the case when working with a "border-line" iron, when the normal fluctuation in the working of the furnace, and composition of the iron, would tend to give too wide a variation in production, even to the extent of obtaining castings scrapped through machining difficulties on the one hand, or porosity and open-grain troubles on the other.

From the foundry point of view, a very far-reaching result of the equalisation of structure which can be obtained with a nickel iron is the extraordinary closeness and freedom from porosity in heavy sections, and at junctions of sections where drawing is likely to occur. In foundry production, nickel is proving very beneficial in cutting down the number of scrap and waste castings owing to porosity and openness and is overcoming difficulties which repeatedly occur in certain classes of work.

The illustation, Fig. 2, shows one of these very important applications of nickel and is typical of many others. In many pistons, trouble is invariably found in obtaining a sound boss, in the middle of a skirt which has to be machined right up to the extreme edge. If silicon is increased in order to obtain the desired machinability, then porosity very frequently will make its appearance in the boss. Several firms interested in nickel have found its application in connection with the production of pistons eminently successful and are obtaining results such as are illustrated. The piston on the right shows the usual form of porosity which occurs in this particular design, when the mixture was controlled so as to give a uniformly machinable casting. By the reduction of silicon, this casting was rendered sound, but chill spots on the bottom of the skirt spoilt the machinability. By the addition of nickel this trouble has been entirely overcome, since nickel restores the machinability of the casting without giving any tendency to openness in the heavy sections. In Table I the analyses of these two pistons are given, and also comparative Brinell hardness figures for the boss and the skirt.

Such castings as couplings, and gear blanks requiring easy machinability on the flanges, often show porosity in the centre boss. As in the case of pistons, nickel has provided a solution of this trouble for many foundrymen. In such applications several firms have found that the addition of nickel results definitely in reduction of scrap and waste castings, thus maintaining the production rate of the foundry and giving a more reliable product. Each foundryman will no doubt find similar applications in his own work.

TABLE I.—*Comparison of Pistons in Normal and Nickel Irons.*

	Normal iron.	Nickel iron.
T.C.	3.35	3.35
Si	1.8	1.6
Mn	0.8	0.8
S	0.12	0.12
P	0.25	0.25
Ni	—	1.0
Boss	Unsound	Sound
Brinell—		
Boss	190	200
Skirt	241	235

Soundness of Heavy Sections.

Remarkable results have been obtained on the use of nickel in castings of heavy section which require to withstand pressure. Illustrated in Fig. 3 is a section cut from the middle of a cylindrical block 6½ in. dia. and 15 in. long and cast on-end. The analysis shown for this section indicates that the normal elements in the iron are present in the usual proportions, and 1 per cent. of nickel has been added. The hardness-figures taken across the section illustrate the remarkable soundness which is obtained in the very centre of this heavy block. The hardness-figures shown in the example is 196; other blocks of a similar nature have been prepared, and the analysis and hardness-figures obtained on these are given in Table II.

They also illustrate this feature of remarkable uniformity throughout the section. It should be mentioned that no special casting precaution was taken except that a head about 6 in. high was cast on the end of the block, the casting being made in cold, dry-sand moulds. No figures are available at the moment for a comparison between these and ordinary cast iron containing no nickel, as sound castings could not be obtained in this latter case.

As a more practical application of this feature, certain castings were made up which were required to withstand extraordinarily high-pressures between holes bored right through the centre of heavy sections. A particular example of such a casting is virtually a solid block 20 in. square by 5 in. thick and contains only two small cores, apart from slight recessing on one side. The lower side of the casting has to be machined to give a working face and various ports and holes are bored through the casting, whose sections in most directions are on the average 6 in. thick. A pressure test of 4,000 lbs. per sq. in. is then applied between these various ports and the casting must prove itself absolutely pressure-tight. Nine of these castings were made by various methods from an ordinary cast iron and were all scrapped. In the present run, nine of these castings have been made up from a mixture whose typical analysis is:—T.C., 3.3; Si, 1.12; Mn, 0.8; S, 0.16; P, 0.4; Ni, 1.0; and Cr, 0.3 per cent.

TABLE II.—*Hardness Figures across Sections of Sand Cast Blocks 15 in. long × 6½ in. diam.*

	T.C.	Si.	Mn.	S.	P.	Ni.	Cr.
(*a*)	3.29	1.06	0.95	0.12	0.24	1.01	—
(*b*)	2.93	1.08	0.83	0.11	0.24	0.77	0.235
(*c*)	3.27	1.21	0.88	0.22	0.21	0.75	0.25
(*d*)	3.20	1.12	0.90	0.13	0.28	0.71	0.21

Hardness across section.

(*a*)	207	196	196	196	196	196	196	—
(*b*)	207	207	207	207	207	207	207	—
(*c*)	187	179	179	179	179	179	187	187
(*d*)	207	207	207	207	207	207	207	—

FIG. 3.—SECTION ACROSS THE CENTRE OF LARGE CYLINDRICAL BLOCK IN NICKEL IRON.

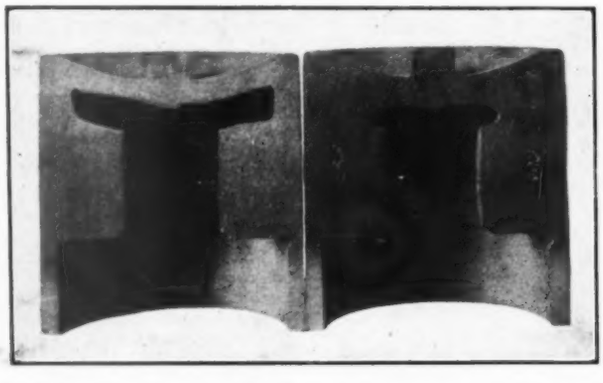

FIG. 2.—TWO PISTONS, OF WHICH THAT ON THE LEFT IS MADE FROM NICKEL IRON.

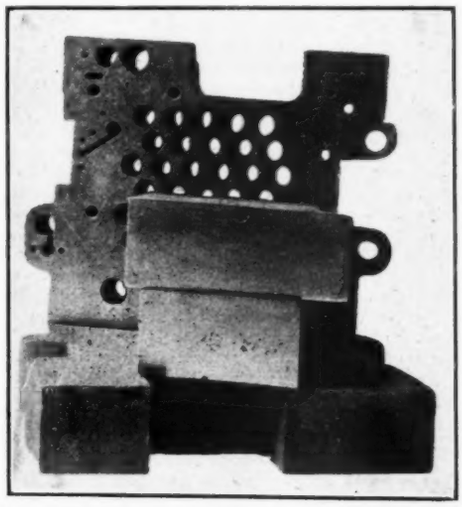

FIG. 4.—SECTION OF PLATE PRESSURE CASTINGS IN NORMAL AND NICKEL IRON.

The castings were cast in cold, dry-sand moulds, and all of these have passed the tests satisfactorily. In this case, the opinion in the foundry is that the use of nickel in the iron has made this casting possible and has saved an extremely expensive and difficult machining job in steel, and incidentally the advantages of good wearing surfaces have been obtained in the iron casting. A similar application is illustrated in Fig. 4, a cast-iron plate which forms part of a modern type-setting machine. The form of casting, which is roughly about 9 in. square and 2 in. thick, is clearly seen, and the machined plate in the background illustrates the severity of the service requirements of the casting in that pneumatic pressure is applied to the various bored-holes and there must be no leakage between one hole to the next. The two sections in the foreground were taken from castings made under exactly similar conditions except that for the upper section, silicon had been reduced in the iron and nickel was added. The analysis of the two irons are given in Table III. The unsoundness of the ordinary iron is clearly seen; and these castings often required to have the holes drilled through them, subsequently bushed with cast-iron bushes in order to make them pressure tight. The nickel-iron in this case gave a sound casting which has given

TABLE III.—*Plates subject to Pressure Test.*

	Normal iron.	Nickel iron.
T.C.	3.4	3.4
Si	1.8	1.54
Mn	0.8	0.94
S	0.14	0.07
P	0.25	0.12
Ni	—	0.91
Plate	Unsound	Sound.

entirely satisfactory service. These examples are typical of the soundness which can be obtained in heavy sections by the use of nickel in cast iron.

Many other applications in the foundry will occur in castings which give trouble due to openness and porosity. In this connection active interest is being taken in the use of nickel in locomotive cylinder castings, which notoriously

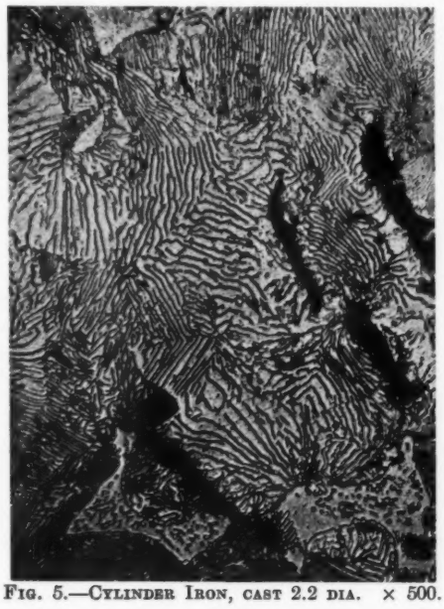

FIG. 5.—CYLINDER IRON, CAST 2.2 DIA. × 500.

give trouble with porosity at the junction of the sections where the piston-valve-chamber and steam-ports join the cylinder proper. In certain of these castings, caulking has been considered inevitable, but it is believed that, although this may not be entirely eliminated, it may very easily be reduced by the use of nickel in an iron of suitable composition, and experiments are now proceeding on these lines.

Cylinder covers of all forms are also notorious for giving trouble with porosity at change of section or at the junction of varying sections, and here again nickel is being applied successfully to the production of sound castings. In the case of one jobbing foundry, one out of every

FIG. 6.—AS FOR FIG. 5, WITH 1 PER CENT. NICKEL ADDED. × 500.

two castings of a water-jacketed cover off a difficult pattern were scrapped; the silicon content of the iron was reduced from 1.8 to 1.5 per cent. and 1 per cent. nickel was added. Since then the scrap loss has been reduced, so that at least three out of four castings are now entirely satisfactory, and it is hoped that with further modification of the composition this figure may be improved upon further.

Interest in the use of nickel in the production of sound and close castings is also reaching to the production of many small pump parts for valve castings and general hydraulic castings and for various gas-engine castings such as breach-ends.

The thoretical explanation of this benefit, which can be obtained by the use of nickel, lies undoubtedly, as mentioned before, in the equalising action of the alloy addition. In irons which tend to show coarse, open structures in heavy sections, improvement is obtainable by the reduction of silicon. The subsequent addition of nickel gives the necessary control of the machinability of the casting without tending to open up the structure in thick sections. The photomicrographs, Figs. 5 and 6, show the effect of the alloy on the pearlitic structure of the iron, indicating a very marked refining influence which is associated with the improved hardness and density of the structure. As a general rule also, a finer form of graphite is associated with the alloyed iron.

Function of Chromium.

In some of the analyses and examples of applications of nickel, given in this Paper, chromium is found associated with the nickel. The action of chromium has been fully investigated and explained.[3] [4] Briefly, it may be repeated that to obtain the maximum benefit from nickel a suitable adjustment of composition should be made in the iron, so that the machinability of the casting is maintained; in other words, so that the iron before and after alloying should demonstrate a constant depth of chill under given conditions. In order to achieve this end, it is usually recommended that the silicon content should be reduced. Equivalent values for nickel and silicon in reducing chill have been worked out, and in practice it is usually found satisfactory to replace each part of silicon by three or four parts of nickel. Under certain circumstances, however, it is not easy, nor perhaps desirable, to make this silicon reduction, and it is under these circumstances that chromium is added with nickel so as to obtain the maximum benefit in the iron.

As far as experience shows up to the present, it is doubftul as to whether the maximum benefit in cast iron is obtained by the use of reduced silicon and the addition of nickel or by the simultaneous addition of nickel and chromium with no alteration in silicon-content. In general, however, with medium or higher silicon, a reduction of this element on making the alloy-addition is preferred, not only as giving undoubted improvement in properties in the iron, resulting perhaps in a greater elimination of porosity, and a general densening of the finished castings than would be obtained by the addition of chromium, but also, since this method is the cheaper as regards cost both of base iron and alloy additions.

It is frequently found, however, that in irons of low silicon-content used for heavy-section work, or in heat-resisting castings, under conditions where it would be difficult to reduce silicon further, very great improvement is obtained by the simultaneous addition of the two elements. Clearly then, in every case, economic conditions as well as current practice in the foundry must be considered in planning development work, and deciding on the optimum method of employing the alloy additions.

The influence of an addition of nickel and chromium on the matrix of the iron shown in Fig. 5 is illustrated in the photomicrograph, Fig. 7. These three micros were taken at the centre of the I.B.F. "L"-size bars (cast 2.2 in. dia.).

Influence of Nickel on Machinability.

Having considered briefly the application of nickel in cast iron from the point of view of the production of castings in the foundry, it is now proposed to give some consideration to the effect the use of nickel will have on the subsequent

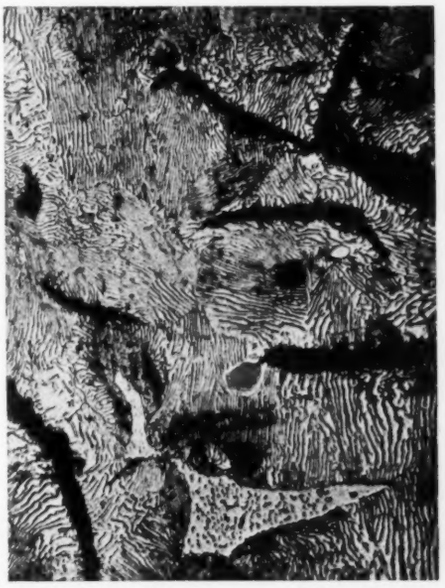

FIG. 7.—AS FOR FIG. 5, WITH 0.85 PER CENT. OF NICKEL AND 0.25 PER CENT. OF CHROMIUM ADDED. × 500.

machining and other operations to which the castings are subjected. It has been shown in much of the earlier experimental work that perhaps the most important influence of nickel lies in its power to eliminate chill and hard

spots.[3] Nickel accordingly is now finding extensive application where machining trouble has occurred through the occurrence of hard, chilled spots, and numerous examples of the application of nickel to overcome this difficulty are coming to hand. As an example, a firm which makes many hundreds of castings of a small connecting rod, which has to be drilled at each end, were having trouble with this machining operation, and, as will be appreciated, serious dislocation was liable to occur in production if a tool broke through encountering such a spot. It was not easy in this case to work a special mixture of iron for these castings owing to the fact that one or two standard mixtures only were run from the cupola, consequently it had become the practice to anneal these particular castings in order to obtain the machinability which was required. Fresh trouble arose here through warping during the annealing process, and yet another operation became necessary for checking up and straightening the castings. With the introduction of 1 per cent. nickel, however, into the iron, uniform machinability is now being obtained, and the subsequent annealing with its associated troubles has been entirely eliminated.

Such an example points to another useful application of nickel, in that in a jobbing foundry where a large number of castings of different sorts are produced, nickel may be used to cut down the number of different metal-mixtures, which are required to accommodate all the different classes of work in progress. Thus in the case of one foundry whose production varies from large cylinder-castings for Diesel-engines down to very small air-cooled petrol-engines, four grades of high-quality iron were usually run for the different classes of work. Now, however, following the introduction of nickel for certain of the castings, it has been possible to reduce the number of metal mixtures to two, and incidentally these mixtures are the cheaper ones to work in that they are of lower silicon-content and contain greater amounts of steel-scrap. The illustration Fig. 8 shows a small air-cooled petrol-engine which in the cast condition is overall just over 6 in. high and has a cylinder bore of 1¼ in. This casting is being made in this foundry very satisfactorily and with uniform machinability from a metal mixture regularly run for much heavier castings, and 1 per cent. nickel is added in the ladle, this eliminating special charges for this work.

No evidence has been obtained of any loss of fluidity in cast iron by the addition of nickel up to 1 or 1½ per cent. even when the nickel is added in the ladle. Extensive experiments

Fig. 8.—Small Air-cooled Petrol-engine Casting.

have also shown that the nickel iron has the same shrinkage as has the ordinary. The commonest example of the need for uniform machinability is perhaps found in connection with automobile-engine-castings and pistons. Fig. 9 gives an illustration of a normal automobile-engine-casting, and it will be appreciated how much machining is required on the outer parts of the blocks, including the three faces on the side which are attached to the thin water-jacket, whilst the vital portions of the cylinder are not only of heavy-section but have their cooling seriously retarded through the mass effect of the casting and through the heat generated by the burning of the oil in the cores.

Many manufacturers of cylinders would prefer to use a hard iron, but in the normal operation of the cupola they dare not get too near the border-line for fear of having the castings unmachinable. By the incorporation of a small percentage of nickel, perhaps of less than 1 per cent., uniform machinability may be obtained, even in castings made from a harder and stronger mixture than had previously been used.

For obtaining uniform machinability, nickel is finding ever-increasing applications in various industries, and one important manufacturer of

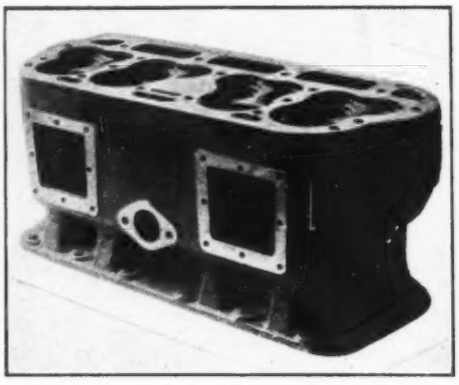

Fig. 9.—Automobile Engine Block.

engine-castings is known to add ½ or ¾ per cent. nickel to a large proportion of his products for this purpose. Nickel is rapidly serving a similar purpose in other industries such as in the manufacture of textile and agricultural machinery; in fact in all cases where small castings are turned out on a mass-production basis, and the inconvenience caused by the breaking-down of a multiple tool through unmachinability of the castings becomes a very serious factor in hindering production.

The use of nickel, however, in this connection is not by any manner of means confined to small castings, for considerable interest is being shown in its use in even very large castings such as rollers for paper-making machinery, sugar-machinery, and so on. Usually, in these cases, the problem is to obtain a good machinable iron which will take on a high polish and a good hard-finished surface, for which a close-grain is clearly essential.

Properties of Nickel Cast Iron.

The influence of nickel in improving production in the foundry and machine shop has been considered, and it is natural to expect that benefit would be derived from that improvement, in the association of better properties with the castings made under these conditions. This improvement, resulting in better service from the castings, is being demonstrated daily, and a large part of the argument for the use of nickel depends on this enhanced quality of the final product. This improvement in properties is undoubtedly closely related to the improvement in production which has already been dealt with, and can very largely be referred to the equalisation of structure and resultant soundness in heavy sections which accompany the general closing-up and densening of the grain of the iron.

Improved Wear.

One of the first results of this denseness of internal sections is that castings can be obtained which show definitely improved wearing properties, and on this account nickel has already proved its worth in assisting in the production of castings which possess a longer life. Perhaps the best-known example of this is the case of automobile-engine blocks and liners. It is not yet possible to produce actual statistical evidence of this, since experiments which are in hand at the moment will take months, if not years, to complete in order to obtain reliable measurements of wear in service. No reliance can be placed in accelerated laboratory tests for measuring this property, since the life of an iron will depend entirely on considerations of loading, lubrication, and so on, which conditions cannot be reproduced effectively in the laboratory. Several manufacturers, however, have demonstrated to their own satisfaction that improved wear is obtained by the addition of nickel-chrome to their ordinary iron, and one would expect that this improvement would be seen also in the corresponding low-silicon nickel-iron. Other manufacturers of both private and commercial motor-vehicles who have experimented for themselves confirm this and report, as a result of extensive bench- and road-tests, that a very marked improvement in the life of cylinder-blocks is demonstrated by the alloy-irons.

The call for improved life in connection with commercial and public-service vehicles is more urgent generally than is that in the case of the private car. One manufacturer, who made some nickel-chromium blocks containing an addition of 0.7 per cent. of nickel and 0.25 per cent. chromium in his ordinary iron for this heavier class of work, found, after the engine was run for an equivalent of 11,000 miles at 48 miles per hour, that there was no measurable wear at all. This is very surprising in that the initial wear of the cylinder block is invariably the worst in normal service.

In this connection a similar application of nickel-chromium is found in centrifugally-cast cylinder liners containing nickel and chromium, which are turned out on a production basis in order to obtain improved service from these castings. Other applications of nickel in cast iron to improve its wear are coming to light day by day, amongst which mention may be made of certain heavy machinery parts, such as lathe beds, in which well-finished, good-wearing surfaces are required.

Improved Mechanical Properties.

Nickel cast iron is finding extensive application also in consequence of the improved strength and resistance to impact which has been demonstrated for it,[4] which, added to the good wearing qualities of the material, render it eminently suitable for such castings as die blocks. It is recorded that certain firms are finding that a nickel-chrome, cast-iron block will often give better service than a steel block, and are now using regularly a nickel-chrome iron for this purpose. There is no special feature in this iron apart from the addition of nickel and chromium, as is shown by the following analysis, which is taken from a die block which successfully replaced a similar part in steel, and clearly at a greatly-reduced cost:—T.C., 3.45; Si, 1.24; Mn, 0.61; S, 0.137; P, 0.54; Ni, 1.67; and Cr, 0.39 per cent. The actual life of this block was several times that of its steel counterpart.

In virtue of its action in densening and strengthening an iron, considerable interest is now being shown in the application of nickel to grain rolls, for producing a harder and better wearing surface. In this application it would appear that the best results may be obtained by the use of nickel and chromium together in the iron, since initially the silicon in a roll iron is so low that it would be a matter of some difficulty to reduce it further without extensive modification of furnace charges and control. The improvement will also result in better wear of the roll journals and general improvement of strength, all of which will undoubtedly tend towards better service.

Other applications of nickel cast iron, in view of its increased strength and toughness, are too

(*Continued on page 67.*)

Methods of Testing Cast Iron.*

By A. le Thomas and R. Bois.

[FRENCH EXCHANGE PAPER.]

(*Continued from page 50.*)

Method of Carrying Out the Frémont Tests on Castings.

The test-pieces are small, either a cylinder about 20 mm. and 5.64 mm. in dia. for the shear test, or a prism 8 × 10 × 35 mm. for the static-transverse test. For the shear test, the test-piece will be taken with a trepan drill, by means of a portable boring machine, from all the parts desired, the hole being stopped with a plug. As the latter is only 11.5 mm. in dia., the operation does not, as a rule, affect the strength of the casting. It should be noted that it is possible to go to any depth, so that in this way a sample of the metal can be taken from the interior of a thick wall. As the shear test is the routine test it is, as will be seen, very easy to carry out.

The static-transverse test, it is true, requires rather a larger test-piece, although it also is small. As it is used only for castings generally of large dimensions (see typical specification given at the end of the Paper), it is easy to take it also directly from the casting.

There are cases, however, where owing to the trepan drill being temporarily unavailable, where the casting is such that it would be unwise from considerations of strength to drill it, or where the part in question is particularly delicate and its strength might be affected by the insertion of a plug, it is impossible for the sample to be taken from the casting. It is in that case necessary to produce at the point selected a small boss forming part of the casting, its length along the axis being a few centimetres and its section approximately the thickness of the wall. This boss will be cut in the mould during moulding by means of a cylindrical tube of the required diameter, which is let into the mould-wall to the necessary depth. After stripping the casting the boss is detached and the test-piece is taken from the centre and as close as possible to the face which adjoined the casting. As the mass of the boss is very small in relation to that of the casting and as the ratio of their calorific capacities is also very small, the cooling of the casting is practically unaffected and that of the boss is identical with that of the wall to which it was joined. Thus carried out, therefore, the test is entirely justified and may be substituted for the method of taking the test-piece from the interior of the casting.

As regards the ball-test, it is obvious that it can be carried out at any point in the casting desired by means of the portable Baumann machine or any other apparatus ensuring sufficient precision. This test will enable the homogeneity of the casting and its general soundness to be ascertained. In the case of several castings in series, cast from the same ladle, it will enable their uniformity to be compared; not, of course, that identity of hardness proves identity of substance, but because identity of substance implies equality of hardness. The Brinell test will give, if not the certainty, at least a strong presumption regarding the equivalence of the mechanical properties of several identical castings poured under the same conditions, and will simplify the method of their inspection. Portevin has given the best proof of the efficacy of this test by reclassifying during the war semi-steel shells in lots which later were found perfectly satisfactory when fired, whereas their classification according to the cast produced a most heterogeneous collection.

It should be remembered, moreover, that the micrographic examination and chemical analysis which is recommended in addition to the mechanical tests can be carried out very easily on shear and static-transverse test-pieces, and this will extend the field of investigation of the microscope to the very centre of the castings.

To sum up, the inspection and specification tests for castings will be the shear, static-transverse and ball-tests. At the end of this Paper is given a specification based on their use. The long series of trials of the Frémont tests has justified their principle and the method of applying them which has just been described. It comprises thousands of results confirming personal conclusions.

Criticisms of Methods outlined for Testing Castings.

The solution just described, which settles the problem of the characterisation of engineering castings so simply and surely, has not been generally adopted in many foreign countries, particularly England and the United States. In these countries the Frémont methods have as yet been little studied, and the testing of finished castings is done on bars cast separately by means of the tensile, shock and transverse tests. Before examining the characteristics of this method and demonstrating that it is bad, it is proposed to review the various objections that have been raised against the Frémont methods. They are nearly all included in a Paper on "The Test-Bar Problem and Some Recent Developments," presented by Pearce to the Sheffield Branch of the Institute of British Foundrymen.

The first objection—and it is this which appears to trouble the majority of objectors—is that it is impossible to judge a casting by a test made at a single point of it. According to Pearce, when referring to the shear test:—"The objection to the Frémont test lies mainly in the fact that it attempts to test the casting by such a small size of bar. On a single small piece, several shear tests can be made and averaged, from the skin of the casting inwards, but such an average is meaningless when applied to castings of different thicknesses. The test appears ingenious for research purposes . . . but for routine testing it cannot be recommended." Here is proof of the complete misunderstanding of the Frémont method. No one ever thought of classifying a casting by a figure obtained from a single test. This is one of the many reasons for which testing on a separate bar was rejected. The test carried out at one point only gives the mechanical value of the casting at the particular point in question, and our method of testing makes no other claim but that of examining the important points, sufficiently numerous and judiciously distributed to furnish an index of its mechanical physiognomy. Moreover, it has been fully demonstrated that a machinery casting is heterogeneous, and it would therefore be absurd to judge it on the examination of a particular point. It will, perhaps, be objected that the specification postulated provides for the taking of a number of test-pieces in proportion to the weight of the casting, and that the strict application of the rule laid down leads to only one test-piece being taken in the case of small castings. But in that case the casting is characterised by the result of the shear test and by the ball-tests, of which a sufficient number are made in addition. This is not in contradiction with the principle enunciated that a single figure resulting from a test cannot give the characteristics of the casting. For, assuming that the point chosen is one of the weakest among those which will be subjected to hard wear, the shear test guarantees a minimum strength as regards all the other parts of the casting, when the testing point is judiciously chosen and the casting is roughly homogeneous, which is ascertained by the ball-tests.

The second objection raised is that the test-piece is too small, whether in the shear or the static-transverse test.

Again, according to Pearce: "The suggestion to test a bar of such small diameter cannot be viewed without apprehension," and the expression "such a small test-piece" is repeated several times in the Paper. The authors are unable to see why the use of such a small test-piece is unjustifiable. What, then, must Pearce think of the ball-test which makes use of 25 mm². of the surface of the casting, or of a micrographical examination which embraces an area one-tenth as large? Yet these tests appear to him legitimate because a sufficient number of them are carried out at all points desired in the casting. The same is the case with the shear test. To those who may be disposed to object that the graphitic aggregates or even the plates of cementite or ferrite, which sometimes attain the dimensions of some tenths of a millimetre, are not sufficiently small in proportion to the dimensions of the test-piece, it may be pointed out that according to Czochralski a metal test-piece may be regarded as quasi-isotropic when a transversal dimension encounters ten particles.[10] By adopting 5 mm. as the transverse dimension of the test this condition is fulfilled. It is therefore quite legitimate to make tests at one point even of a large casting with small Frémont test-pieces.

It would seem, however, that this British writer has not entirely freed his mind from recollections of the old theory, which consisted in testing a large casting by means of a large test-piece, the only purpose of which, however, was to obtain in the two cases rates of cooling which were only too dissimilar.

Objection is also taken to the Frémont test-pieces on the ground that it is impossible to take them from the castings, at least in routine work: "The design of a casting," according to Pearce, "is based on the strength of the material of which it is composed, but this cannot ordinarily be checked by testing the casting itself. It is necessary to make the test by a test-bar." And, a little further on: "Ordinarily it is not practicable to test the casting itself. Furthermore, in ordinary cases it is not practicable to cut the test-bar from the casting. This being so, there are two alternatives: (1) A test-bar can be cast as an integral part of the casting; and (2) the test-bar can be cast separately, but with the same ladle of metal as that from which the casting is made."

The methods habitually employed when taking test-pieces from the castings are extremely simple, whether the casting is drilled directly with a trepan mounted on an electric boring machine or whether a sawn-off boss is used. Since employing this method the slightest difficulty has never been experienced, whatever may have been the size or shape of the casting. It is, therefore, regrettable that, as the taking of test-pieces from the castings appears to have been found impossible in England, most of the work carried out under the direction of the Cast Iron Research Association has been done on separate bars.

Test-pieces taken from the casting or cast integrally with it are also criticised on the ground that their cooling is affected by that of the casting. "In the case of a cast-on bar," according to Pearce, "the cooling is complicated by that of the mass of the casting," and, later: "The logical procedure, therefore, is to cast a bar from the same metal at the same time as the casting; this method excludes the influence of the proximity of the casting."

The authors have sufficiently demonstrated how, on the contrary, this cooling influence of the casting is necessary, since the object in view is to obtain a test-piece with precisely the same rate of cooling. This, moreover, is why we reject the principle which consists in taking pieces connected with the castings by means of two or more small channels and having dimensions inde-

pendent of those of the castings, the result of which is that the influence of the cooling of the casting on that of the test-piece is to a great extent eliminated, and the sole utility of which is to prove that the test-piece and the casting were actually cast together.

With regard to taking test-pieces from an attached boss, this method meets with the serious criticism on the part of Pearce that it gives an inaccurate result: "Experience may enable a cast-on bar to be so placed and dimensioned that it does in effect give a strength similar to that of the casting, but such cases must be very rare." It is very remarkable, then, that these rare instances should have occurred regularly in thousands in practice during the last five years. The extended tests made using this method of taking test-pieces constitutes a formal refutation of this criticism.

Finally, according to Pearce, the method of taking test-pieces from the casting prevents any comparison being made between the results obtained in different foundries. "Comparison between the results from cast-on bars," he says, "is impossible." And again: "With such a bar (cast separately) it becomes possible to compare the results from different foundries and from the same foundry on different days." It must not be forgotten that the individuality of each casting makes it difficult to compare it even with a casting of the same type poured with the same metal from the same ladle. It would, therefore, be absurd to attempt to compare intrinsically different metals when one metal is not even comparable with itself. A comparison of the metals must be made on different well-defined test-pieces, which will be real test-pieces of the utmost simplicity, and for that reason comparable. This comparison of the metals, however, has nothing to do with that of the casting, and if that of test-pieces taken from the castings is not possible, it is for the simple reason that these castings themselves are not comparable.

To sum up regarding the objections raised against the Frémont methods as used by the authors, viz., the isolated nature of the test, the smallness of the test-piece, the impossibility of taking the piece from the casting, the inaccuracy of the results given by pieces taken from attached bosses, and the non-comparability of the results obtained—some of them are refuted by the long-continued use of the tests, while the others fall to the ground if one will only consider for a moment the principle and the import of the method.

Method of Testing Castings on Separate Bars.

Description of the Method.

As to the testing method which is upheld against those outlined, the principle of this is to make the tests on separate test-bars cast in a special mould with the same metal as the casting. It is favoured chiefly by British and American founders, whose specifications are very similar, and it will again be Pearce's Paper from which its definition is derived:—"The logical procedure, therefore, is to cast a bar from the same metal at the same time as the casting (in a green-sand mould for a green-sand casting, in dry sand for a dry-sand casting)." The dimensions and shape are specified for three standard types recommended by the British Engineering Standards Association, and are given in the following table:—

Shape.	Diameter.	Distance between supports in transverse test.	Maximum thickness of castings represented by test-pieces.
	In.	In.	In.
Cylindrical ..	0.875	12	¾
Cylindrical ..	1.2	18	2
Cylindrical ..	2.2	18	> 2

The medium test-bar has been adopted as the standard type in America, under the name of the "arbitration bar." The cylindrical form was chosen because in the tests it gave results showing higher values than bars with a square or rectangular section. The cause of this phenomenon has been ascribed by Norbury to a difference in crystallisation at the angles. In reality, all that can be proved by his experiments—the results of which are given in Pearce's Paper—is that the influence of angles, if they have any, does not operate alone; but the greater strength of round test-bars may equally well be due to a difference in the distribution of the stresses in the two types.

The tensile test-bars must necessarily be machined, but not the transverse bar, which would show a higher strength figure in consequence. As regards the dimensions chosen, there are three categories. "It is not satisfactory," according to Pearce, "to cast bars less than 0.875 in. thick, and this is the diameter of the smallest bar in the specification. It is taken as representing castings up to ¾ in. across the main section. Very heavy castings cannot be represented by too big a bar, as the breaking load must be within the limits of ordinary testing machines. The larger bar recommended is, therefore, 2.2 in. dia., to represent castings whose main section exceeds 2 in. The medium bar of 1.2 in. probably represents the bulk of engineering castings." It is on these test-pieces that the tensile, transverse and shock tests are carried out.

Criticism of the Method.

It has been shown in the first part of this Paper that the shock and tensile tests were adopted wrongly. The British test-bar is cast separately. It is, therefore, possible that it may have the same composition as the casting. There is no possibility of its having the same crystalline structure, as the conditions under which the cooling of the casting and the test-bar might be similar are systematically discarded. The result is that two castings entirely differing in form and in the distribution of their masses, but cast from the same ladle, and such that their thicknesses classify them in the same type of test, will be represented by the same test-bar, which is absurd, for they are as dissimilar mechanically as two castings produced from two metals chemically different.

This objection is in itself sufficient to justify the rejection forthwith of the method of testing castings by separate test-bars, and no argument will ever be able to prove the contrary. How can a casting be interpreted by a single result? For this the material composing it would have to be homogeneous, and the test would have to be applied to the material. Neither of these conditions, however, is fulfilled. Pearce criticises the Frémont method for testing a casting with a single test-piece. A test at a single point, he says, "is meaningless if it is intended to represent castings with different sections or different sections of the same casting." The authors do not appreciate how the separate test-piece is capable of doing this. Yet this is precisely the function which its advocates claim that it performs.

They would also like to know what are the reasons that governed the choice of the number of kinds of test-bar and their dimensions. How ought a casting with a maximum thickness of 2 in. to be tested—with the small or the medium bar? The results in these two cases will be different, and even incapable of comparison, as the transverse test is made with a distance of 12 in. between supports in the first case and 18 in. in the second. Similarly, how are castings to be classified according to mechanical value when some will have to be tested on the medium and others on the small test-bar?

It must be noted besides that the reasons which determined the choice of the bar's dimensions have no relationship with the castings which they are required to represent. In the case of the large one, for example, "not too big a bar was chosen, as the total breaking load must be within the limits of ordinary testing machines." All the conditions governing the casting of the test-bars, moreover, were laid down after discussions in which one important consideration seems to have been that of obtaining from the test the highest possible figure, whatever its significance might be. Thus, with reference to the transverse test, Pearce states: "If deflection is wanted, the bar should be machined, but if stiffness (high breaking load) is required, it should be tested as cast."

Finally, separate test-bars are subjected to the special condemnation of cast-on pieces expressed by Pearce, viz., that special attention is given them by the founder to the detriment of the casting itself. It is much easier, in fact, to fake a separate test-bar. To sum up, the separate test-bar is incapable of representing a casting, and no arguments can exist to justify the method of testing based on its use. The work done in England on these lines has not therefore solved the problem of testing castings. It, however, furnishes interesting data for the establishment of a method of testing the metal as such. This, moreover, is of considerable value from the point of view of research—as regards improving the composition of a charge, for example. But this interpretation of "the metal in the ladle" has nothing in common with that of the castings themselves, and one must be very careful not to assume that because a metal has given excellent results on separate bars it will produce castings of excellent quality. The two things are entirely different.

Specification for Engineering Castings.

In a previous Paper the authors published a model specification for testing the manufacture of engineering castings. They have been led to modify slightly the conditions required for each category of metal. The following are the provisions at present in force:

Tests.

General Soundness of Castings.—The castings shall be free from flaws, cracks, pipes, gas-holes, cold shut, or any other defects which might injure their strength or render either their strength or suitability in use doubtful.

Scabs, if slight, few in number and such as not to jeopardise the strength and proper working of the casting, shall be tolerated. In the examination of defects, moreover, the directions given below regarding the different qualities of metal shall be followed.

Castings showing defects in any part intended to remain visible after it is erected, which would disfigure their appearance without injuring their strength or their fitness in use, may either be repaired as described below or form the subject of a proposal for acceptance with a discount.

If the castings may not appear absolutely sound the inspector may, before authorising despatch, require the castings to be lightly machined at those parts where this is recognised to be necessary and possible, even if such parts are not intended to be machined ultimately, and subject to the thickness not being reduced below the minimum tolerances fixed above. Should such machining not be practicable the inspector may have the doubtful parts subjected to pickling with dilute acid or to any other equivalent process; he may also, if he considers it preferable, ascertain the importance of the cracks, scabs, pipes, etc., by a test with petrol or water under pressure.

Castings required to be water-tight or steam-tight shall be subjected to a water or steam test for a minimum of fifteen minutes at the pressure specified in the contract.

In castings intended to receive steam no defect, whether repaired or not, shall be admitted, with the exception of slight and localised defects, which shall be repaired as indicated below in respect of the different qualities of metal.

All castings intended to be erected, in which subsequent work may disclose defects prejudicial

to their use, shall be returned to the supplier. The latter shall not refund the cost of machining or other charges incurred by the Navy, but shall refund the cost of the return transport, for which he shall be responsible. Such castings shall be replaced, or repaired if the inspector authorises their repair. In the latter case steps shall be taken after their repair to ensure, by carefully checking the measurements, that their dimensions are sufficient to permit of their being incorporated into an engine.

Nature of the Tests.

The following tests shall be made:—

(1) *Shear tests*, preferably on a test-bar taken with a trepan drill from the casting, but if necessary on a piece taken from a cast-on boss.

(2) *Hardness tests* for the purpose of judging homogeneity, made on parts with the skin removed.

(3) If required, and under the conditions specified below, *static transverse tests* on a bar taken from the casting or from a cast-on boss.

(4) If necessary, and under the conditions specified below, *compression tests* on a test-bar taken from the casting or from a cast-on boss.

Classification of Engineering Castings.

Engineering castings shall be classified in three categories:—(1) Extra strong, (2) strong, and (3) ordinary.

Special Conditions relating to Extra-Strong Castings.

The total number of tests, with the exception of the ball-test, shall be the whole number immediately below the quotient of the weight of the rough casting, serving as the basis for payment, divided by 200 kg., but such number of tests shall not be less than 2 or greater than 5. If it does not exceed two the tests shall be exclusively shear tests. If it is equal to or greater than three, one of the tests shall be a static-transverse test and the others shear tests. All the shear bars must show an average strength of at least 25 kg./mm². The static-transverse bar must stand at least 550 kg. and the breaking deflection must not be less than 30/100 mm.

In case of need, as when the shear-test machine used in the foundry is temporarily unavailable, the shear tests may be replaced by an equal number of compression or static-transverse tests on a test-bar taken from the casting or attached to it. The minimum compression strength shall in that case be 78 kg./mm², and the minimum static-transverse strength of the bar, the deflection not being measured, 550 kg.

Ball-tests distributed over the casting, the number of which prescribed by the inspector shall be sufficient to enable the homogeneity to be verified (on a basis of about one-ball test per sq. metre of surface), shall in principle give a Brinell hardness between 170 and 240. An excess in hardness, however, shall not involve rejection unless it occurs at a part which is to be machined, and a machining test made at such part (by file or machine) gives a negative result; while a deficiency in hardness shall not involve rejection unless a test made on a test-bar taken in the vicinity of the ball-test gives an average shear strength below the minimum allowed (the test-piece being taken, if required, with a trepan drill and replaced by a plug unless the strength of the casting prevents this).

In the case of repetition castings moulded in the same manner and cast with the same mixture (taken from the same ladle), the mechanical tests prescribed above shall be made on only one casting of the series at the option of the inspector. The other castings shall be subjected to ball-tests at least equal in number to the shear (or static-transverse or compression) tests carried out on the same casting. The Brinell hardnesses must remain within the limits indicated above. If any of the tests made on the type casting should not be satisfactory, each casting shall then be subjected to the entire series of tests.

Repair of Defects.

Only defects of extremely slight importance shall be allowed, and only when they quite obviously could not prejudice either the strength or the satisfactory service of the casting. If they impair the outer appearance they may be repaired, but only by plugging.

Special Conditions relating to Strong Castings.

Shear and static-transverse tests shall be carried out in the same manner as for extra-strong castings, except that the total number of them shall be equal to the whole number immediately below the quotient of the weight of the casting divided by 500 kg., but this number shall not be nil or greater than five. If it is less than three the tests shall be exclusively shear tests. If it is equal to or greater than three, one of the tests shall be a static-transverse test, the others being shear tests. All the shear bars must show a minimum average strength of 20 kg./mm². The static-transverse bar must stand a minimum load of 450 kg. and its breaking deflection shall not be less than 25/100 mm.

If necessary, as in the case of extra-strong engineering cast iron the shear tests may be replaced by an equal number of compression or static-transverse tests. The compression strength shall in that case be at least 63 kg./mm², and the static-transverse strength of the bar shall not be less than 450 kg., the deflection not being measured. Ball-tests distributed over the casting, as in the case of extra-strong cast iron, shall in principle give a hardness between 150 and 240. An excess or deficiency in hardness shall not involve rejection until it has been ascertained that machining is practically impossible, or unless the shear strength is insufficient, as in the case of extra-strong castings. In the case of repetition castings, the provisions specified above for extra-strong castings shall be applicable to strong castings.

Repair of Defects.

Only defects of slight importance shall be allowed, and only when they cannot prejudice either the strength or the satisfactory service of the casting. If they impair the appearance they may be repaired by plugging, or the insertion of special alloy (monel or an equivalent).

Special Conditions relating to Ordinary Castings.

In each lot of castings, whether similar or not, but cast from the same ladle, two castings selected by the inspector shall be subjected to shear tests. Both the test-bars shall show a minimum strength of 15 kg./mm². If they do not do so, each casting shall be subjected to the shear test, and only those which fulfil the foregoing condition shall be passed. If necessary, the foregoing tests may be replaced by an equal number of compression or static transverse tests made on test-bars taken from the castings or attached to them. The compression strength shall in that case be at least 48 kg. and the static-transverse strength of the bar at least 350 kg. Moreover, if the test made on the two type castings is favourable, all the other castings shall be ball-tested, their hardness shall be above 130 and below 240, but an excess in hardness shall not involve rejection unless, after trial, the parts intended for machining are not capable of being machined practically; while deficiency in hardness shall not involve rejection unless the shear strength of the casting in question is below 15 kg./mm².

Repair of Defects.

Defects of slight importance which could not prejudice the strength or the satisfactory service of the casting shall be allowed. They may be repaired by plugging, the insertion of special cement or a special alloy, the application of metal of suitable composition, or by any other process sanctioned by the inspector.

THE FRENCH steel-making firm, Société des Hauts-Fourneaux et Laminoirs de la Sambre, is to be absorbed by the Société des Forges et Fonderies de Montataire.

Practical Application of Nickel in Cast Iron.

(*Continued from page 64.*)

numerous to refer to here, but amongst such there are many small machinery parts, such as spindles and bushes, gear-wheel blanks and couplings, for which the improved strength, coupled with the possibility of getting a sounder casting free from porosity in the bosses with ready machinability on the flanges, renders nickel cast iron particularly suitable. Numerous other similar applications will occur in connection with each industry.

Machinable Hardness.

Castings which possess abnormally high hardness and are yet commercially machinable can be produced regularly in alloy cast irons containing about 2 to 3 per cent. of nickel. Castings of this type will show great uniformity of structure, and the nickel is especially valuable in obtaining these high hardness figures, since there need be no tendency to the formation of chilled spots in the castings. Irons of this type are in favour for various castings which are subject to excessive wear, in cases where the slower speed of machining which will be necessary with this type of material is not a serious drawback. It is not uncommon to hear of castings of this type being machined at speeds little below the normal and having Brinell hardness values of 260 or 280, and cases have been encountered in which irons having hardness values well over 300 have been satisfactorily machined.

Conclusion.

In this Paper consideration has only been given to the application of small amounts of nickel in grey cast iron. It should be mentioned, however, that nickel is finding extensive application in white and chilled cast iron, and also that higher percentages of nickel find use in cast iron of various grades in virtue of its influence in rendering the structure austenitic. Space, however, does not permit more than a passing reference to these applications.

The influence of nickel on the properties of cast iron has been well established as the result of extensive research work. In this Paper the practical application of nickel on the basis of this research has been considered. It has been demonstrated that the action of nickel leads to material improvement in the production of high-quality cast iron in the foundry and in the subsequent handling of the casting in the machine-shop. This improvement is due, in part, to the equalisation of structure brought about by the added element and the much greater latitude of the alloyed iron. The improvement thus obtained is proving of the greatest value to foundrymen and engineers, and enables difficult castings to be made successfully where normal compositions of iron, cast under ordinary conditions, have failed. This is especially the case where high-hardness and good-wearing qualities are required on certain parts of castings, which have to show uniform machinability across varying sections; and castings commercially machinable, yet showing very high-hardness values, can be obtained in the alloy iron. The use of nickel in cast iron tends towards a general uniformity of product, which is of great value in production work where variation in machinability is to be avoided.

In the foundry each particular casting presents its own special problems, but it is felt that the examples given in this Paper will give some indication of the lines along which nickel is successfully and economically finding application in cast iron, and indicates some of the benefits which are to be obtained, first by the foundryman and secondly by the engineer through the employment of this material.

The author wishes gratefully to acknowledge his indebtedness to the Bureau of Information on Nickel, Limited, for assistance in the preparation of this Paper and for permission to publish the information given.

XUM

Non-Ferrous Foundry Metallurgists in Session.

DISCUSSION ON MR. DEWS' PAPER* CLEARS UP MANY COMMON DIFFICULTIES.

Fracture Judging.

The President (Mr. Wesley Lambert), emphasising Mr. Dews' remarks with regard to the interpretation of the fractures of bronze, said it was his experience that the majority of engineers could not interpret the fracture of a non-ferrous metal. When a bronze of the nature of, say, an Admiralty gun-metal was ruptured, it was not unusual to hear such remarks as "It is not even mixed properly," "It is made up with a lot of scrap brass; look at those yellow and red patches," etc. Such remarks evidenced the fact that the people who thus commented on a fracture could not interpret the fracture of a bronze. It was essential that the founder should have a correct knowledge of the fracture of each individual alloy, and he should be able to judge by the fracture whether the metal had been correctly compounded, whether it had been cast at too low or too high a temperature, and also whether the mould was sufficiently dry. With the knowledge obtained from the correct interpretation of the appearance of the fracture, combined with the knowledge obtained from the testing laboratory of the tensile and other tests, one should get a good idea of the best standard fracture to work to. The President also emphasised the necessity of adopting a standard method of producing the fracture. It was quite possible, by varying the method of fracture, to produce fractures of quite different appearance from one bar of uniform character. It was quite possible, in the case of both ferrous and non-ferrous metals, to break a bar in such a manner that the rupture would occur around the crystal grains, or in such a way that it would occur through the crystal grains, thereby producing a fracture which appeared to show that the structure was coarsely crystalline, or, on the other hand, that it was of an amorphous or of a fine granular structure.

Two Types of Contraction.

Mr. A. H. Mundey said he was particularly interested in Mr. Dews' work, especially in connection with the mechanism of solidification, which had to be studied very closely in connection with die casting. The contraction of the metal due to crystalline contraction during solidification, and the contraction which occurred after the metal became solid, were two separate functions. Certain metals contracted very little due to crystalline contraction, but they all contracted very considerably afterwards, according to the simple law of lineal contraction—a fact which was often forgotten. It had been suggested to him that surely, seeing that there was such a magnificent sharp impression of the mould, there could be no such contraction. That was not true, however, and that second contraction must be legislated for most definitely. Every patternmaker's rule had a little spare—a 1-ft. rule was a little longer that 1 ft.—so that he might legislate for lineal contraction, but that lineal contraction was quite different from the contraction which occurred during solidification, because the latter varied according to the constitution of the alloy.

Equilibrium Diagram as a Basis.

Mr. A. Logan, emphasising Mr. Dews' plea that foundrymen should try to take an intelligent interest in equilibrium diagrams, said it was only by studying such things and trying to grasp what actually occurred during the solidification of an alloy that they could anticipate with intelligence what would happen inside the mould, and cater for it. Mr. Logan also emphasised the importance of a study of the liquid contraction which occurred on freezing. It was undoubtedly a point about which we knew very little, and the sooner we knew more about it the better.

Mr. W. Cartland pointed out that, although a large number of Papers was published giving the results of investigations of the various alloys from the purely scientific point of view, and occasionally some very severely practical Papers were published, there seemed to be very few links between the theoretical or scientific and the practical. Mr. Dews was to be congratulated on this Paper, because it did form one of the links between the two extremes, and it was to be hoped that many more Papers of the same character would be published.

Effect of Virgin Metals.

Mr. Henry Milner, discussing the relations between works metallurgists and foundrymen, complained that these two departments seemed to be quite distinct in aim and object. Reference has been made by the President to the necessity for educating the foundrymen to a scientific interpretation of fractures, but the only fractures which the metallurgist put before the foundrymen were the bad ones; he never showed and explained the metallurgical points of a good fracture.

Referring to a bronze consisting of, say, 10 per cent. tin, 0.5 per cent. phosphorus, and the remainder copper, he asked Mr. Dews for information with regard to the beads of white material which came back very often on the riser, but not so often on the runner. Also, discussing a bearing bronze, of a composition similar to that of the bronze already referred to, except that it contained 8 per cent. less copper, for which 8 per cent. of lead was substituted, he said that much slag was produced, and he had found it impossible to eliminate it. It seemed to form on the sides of the pot, even though it had been skimmed. It had been stated in some quarters that the trouble could be overcome by the addition of nickel, and he asked whether Mr. Dews had had any experience of the use of nickel in bearing bronzes. With regard to the examination of bronzes, he said that, although the Admiralty called for a tensile strength of 16 tons per sq. in., and an elongation of 10 or 15 per cent., the inspectors acting on behalf of other large customers did not worry about physical tests; they had the bars machined and broken, and examined the fractures, and they contended that that was sufficient. He asked whether Mr. Dews considered that the fracture was a better guide than the physical tests, or *vice versa*.

AUTHOR'S REPLY.

Phenomenon of "Tin Sweat."

Mr. Dews, replying to the discussion, said it was unfortunate that some works metallurgists got into the habit of telling the foundry workers about the bad work only. At the same time, it was the metallurgist's job to root out the bad work and to try to put matters right. Furthermore, they were sometimes reluctant to say what was correct, because conditions constantly improved, and what they one day regarded as perfection would the next day be improved upon. Their attitude was probably also due to the training they received; in science, no sooner did one look upon a thing as being a definite fact, than someone would come along with a new theory, which showed the old ideas to be only partly true.

With regard to the bronze containing 10 per cent. tin and ½ per cent. phosphorus referred to by Mr. Milner, who said that during the cooling he noticed beads of white material on the tops of the runners and risers, the author said that this material was a tin-phosphorus rich alloy, and it sweated out of the bronze just as the bronze was cooling from red heat to black. If the casting being made was a fairly light one, and if a fairly heavy runner was used, one need not worry much if a few of these beads appeared; but if the casting were a heavy one, and beads appeared on the top of the runner, one could be certain that the casting was useless. The beads appeared only when phosphor bronze was cast too hot; if it were cast cooler, the runner top, instead of being level or bulging out like a cauliflower, would sink, and there would be no beads of tin-phosphorus-rich compound on the runner. In the case of a light casting, one could not cast phosphor bronze cold enough to produce this sinking on the riser and runner, which were necessarily heavier than the casting. With the heavier casting, one could pour the metal cooler and could keep the tin sweat down. As a matter of fact, phosphor bronze of this description should be poured as cold as it was possible to run the casting sharp; the temperature should be just a little above that which would result in a cold shut or mis-run.

Leaded Bronzes.

With regard to the bronze containing 8 per cent. lead and 0.5 per cent. phosphorus, he said a slag was produced consisting of lead and phosphorus—a complex lead phosphate. This slag was continually being formed, and would rise to the top of the molten alloy. It was liquid at temperatures below that at which the casting began to freeze, so that one could not thicken it and skim it off the alloy before pouring. At ordinary casting temperatures the slag was so liquid that it was liable to run into the casting. When casting a high-lead phosphor bronze in his foundry, it was the practice to use either a "strainer" head or a fairly large cup with a plug in it, so that one was able to maintain a good head of metal in the runner and to allow only the clean slag-free metal to run into the work. He did not believe there was anything in the proposal to use nickel for the purpose of eliminating that slag, and he knew of no way of overcoming the trouble other than by preventing the slag getting into the work by means of special pouring devices.

Fractures of Physical Tests.

There was a good deal to be said for the practice of examining only the fracture of bronze and disregarding the physical tests. It was possible to pour two test-bars from one pot of Admiralty gun-metal, one of which would have a tensile strength of 8 tons and the other 18 or 20 tons per sq. in. It was obvious, of course, that both of these were not representative of a casting poured from that pot of metal, nor representative of the quality of the bronze. The only way to ensure getting a test-bar to represent the quality of the bronze was to cast about six bars, commencing at a temperature higher and finishing at a temperature lower than that at which one would cast the work. One could then plot the test results on a curve and take the peak as representing the best test one could get out of that mixture. That method was hopelessly inconvenient for practical work, however, and applicable only to experimental work. There was thus a good deal to be said for nicking a piece of metal and examining the fracture, but one needed a good deal of experience before one could rely upon such a method. Founders were familiar with one type of inspector who came to their works occasionally, and, by encouraging such a method of test, we should have, sooner or later, a very inexperienced inspector visiting the works, who would reject castings on what he

* "Practical Points from the Metallurgy of Cast Bronzes." See issue of June 20, page 474.

considered to be a bad fracture, and which the founders themselves might consider to be a good fracture.

Co-operation between Works and Laboratory.

The PRESIDENT said that on several occasions he had pointed out that the founding of metals was not an exact science, and, in view of the many variables that were introduced in the manufacture of castings, especially those of complicated shape, he doubted whether this could ever be expected—a fact which was often overlooked by the purchasers of castings. The purchaser seemed to think that, with the present-day science at our command, one ought to be able to turn out perfect castings, but until the founding of metals became an exact science, one could not always ensure standard conditions. Commenting on the complaint which had been voiced to the effect that the works metallurgist approached the foundryman only when things went wrong, he pointed out that, after all, such a condition of things was more or less to be expected. On the other hand, it was up to the foundryman to educate himself, and there was no reason why the foundryman should not cultivate a sufficiently friendly feeling, between himself and the works metallurgist, to ask assistance from the metallurgist. In a good many instances the metallurgist took it for granted that the foundryman was able correctly to interpret fractures, and that a good fracture would give good test results; if the foundryman did not know what test results to expect from a metal, which he considered to be good, he should ask the works metallurgist to make some tests and to furnish him with the results. He (the President) did not think a works metallurgist, if he was worthy of his position, would ever refuse such information.

With regard to the equilibrium diagrams, he said the ordinary craftsman could hardly be expected to understand or to digest the many diagrams that one found even in the technical literature devoted to the foundry craft. As far as possible, he adopted the practice, when lecturing, of dealing only with that portion of the curve which had relation to the usable foundry alloys, and he carefully avoided dealing with the complete curve and its ramifications. It was, however, advisable for the foundryman to study that portion of a curve which covered the alloy or range of alloys with which he was likely to have to deal. In this connection he (the President) offered to help any foundryman who had difficulty in mastering an equilibrium diagram. If any such would write to him and explain their difficulty, he would be glad to interpret that portion of the curve which related to their particular alloy.

"Tin Sweat"

Discussing the "tin sweat" which appeared when casting bronze as mentioned by Mr. Milner, he confirmed that the constituent which sweated out was obviously the constituent which was the last to solidify. One must regard the first-formed tin-copper casting as a sponge containing in its interstices a constituent which had not solidified. As soon as the matrix or sponge had solidified and had begun to contract, there would be a tendency for the liquid constituent remaining in the interstices to be squeezed out. Obviously, as Mr. Dews had pointed out, it was best to arrive at a temperature for casting the bronze at which as much as possible of the low-melting-point constituent would be trapped in the casting. At the same time, there was something to be said in favour of a little of the tin constituent sweating out, because when that occurred it indicated that the mechanism of solidification of the casting as a whole was proceeding along normal lines.

Discussing further the interpretation of fractures, he suggested that one should fracture specimens in various ways in order to arrive at a standard method, and also to ask the metallurgist to favour with a short lecturette on the interpretation of any fractures so produced. He urged the foundryman to make friends with the metallurgist; if this was done both the metallurgist and the foundryman would learn something to their mutual advantage. Too often a foundryman was inclined to regard the metallurgist as a policeman, and in many instances foundrymen themselves were to blame for not making friends with the metallurgist. Foundrymen did not always appreciate the introduction of scientific instruments intended to aid them in their work. For instance, when a pyrometer went wrong they were inclined to say "Pyrometers are of no use," but if a pyrometer was handled as it should be handled, instead of meeting with the rough usage to which it is often subjected, far less trouble would be experienced and confidence in the use of the pyrometer would soon be established.

Nickel Additions to Leaded Bronzes.

Referring to the bearing bronze mentioned by Mr. Milner, and containing 8 per cent. of lead, he said that, with all respect to Mr. Dews, he would have suggested less phosphorus in the mixture, unless bound by a specification figure. Personally, he could see no valid reason for including a high amount of phosphorus in a bearing bronze containing a heavy percentage of lead. Much slag is invariably formed, which may, and sometimes does, find its way into a casting unless means are adopted to keep it out. With regard to the addition of nickel in lead bronzes, he said that such practice was resorted to more particularly in the case of alloys having a higher lead content than that mentioned by Mr. Milner. Nickel was one of the reagents which were sometimes introduced into bearing bronzes containing 25 or 30 per cent. of lead, the object of the introduction of the nickel being to "hold up" the lead, *i.e.*, to prevent segregation, and in this respect it was effective. Sulphur, plaster of Paris, and other reagents were also used in some foundries for a similar purpose.

Soluble Oxides in Bronzes.

MR. A. LOGAN, commenting on Mr. Dews' statement that there were no soluble oxides in bronze, said that although he did not dispute that statement, it might be profitable to consider what happened when a bronze was maltreated. It was possible to melt in a reverberatory furnace a large amount of scrap—borings, and other metal of that type—and obtain thereby a mixture which a foundryman would refer to as being oxidised. If that metal were run into a ladle it would look very pasty, and a casting made from it would be full of porous places, gas-holes, etc., even though it were cast at the correct casting temperature. Mr. Dews had stated that there were no soluble oxides in the alloy, but the foundryman wanted to know the reason for the state of affairs mentioned, and how it could be remedied. In such castings there was a tendency to excessive segregation, and there was evidence of the "tin sweat" to which Mr. Milner had referred.

Remelted Bronze Borings.

MR. DEWS said that the point raised by Mr. Logan was very important indeed. He believed that the statement in the Paper, that there were no soluble oxides in bronze, was correct, and he made the statement quite definitely. The oxides which caused trouble in the casting of bronzes were, he believed, insoluble, and were held in suspension. Mr. Logan had visited his foundry on the previous day and had seen there a reverberatory furnace which was employed entirely in melting very fine bronze-borings which were taken from the lathes in the shops. These were turned out into ingots, and the ingots were re-melted—with new metal, he admitted—and poured into castings, and this metal never gave any more trouble than other metal with oxides, blowholes, or anything else. In fact, provided the metal were properly melted the second time, he defied any foundryman to tell the difference between a casting made from new copper and tin and one made from the dirtiest old borings swept up from the floor of the shop. It was merely a question of allowing sufficient time for the oxides, scum, dirt, and so on, to rise to the top of the metal, and then skimming it off. One could add a little phosphorus, to make it more fluid in order to allow the oxides to get to the top so that they could be skimmed off. He had never noticed any tendency for tin sweat to occur in metal made from borings or scrap any more than in new metal.

Gas Content in Metals.

MR. A. H. MUNDEY said that many foundrymen missed or overlooked the fact that, of the oxides in gunmetal, tin oxide was not deoxidised by phosphorus. Copper oxide was deoxidised by phosphorus, but tin oxide must be coaxed to the top of the metal and skimmed off. It had been pointed out by Griffiths, two or three years ago, that tin oxide was some two and a-half times as hard as tool steel, and the presence of little bits of it in a bearing bronze was bad. Again, metal which had been melted very quickly, or had been standing very hot for a long time, occluded a very large quantity of gas. That gas had to be removed, but if the metal were cast badly or at too high a temperature it did not get rid of the gas. The conditions were the same as in steel casting.

Reclaimed Scrap Metal Satisfactory.

The PRESIDENT said there was a tendency among foundrymen, when having to make a casting wholly from a scrap mixing, and which casting failed to turn out quite right, to blame the trouble on to the use of scrap. The point to be considered, however, was the nature of the scrap. If, for instance, one had supplied a number of perfectly good castings to a customer, and for some reason or another those castings were returned, one could not justly refer to those castings as scrap in the general acceptance of the word. Foundrymen should be too proud to attribute many of their troubles to the use of scrap; the fault was in the treatment of the metal rather than inherent in the metal itself. In the ordinary way one could make very good castings from remelted scrap.

Second Melting.

MR. A. H. MUNDEY agreed that better results were obtained on second melting than on the first melting, and emphasised the point by means of an analogy. If one went to a chemist's shop and asked for a bottle of medicine according to a prescription, the chemist would not prepare it by putting into the bottle a teaspoonful of Epsom salts, fill the bottle with water, and then add sugar and a little cochineal, and charge 2s. 6d. If he did that, one would not be prepared to pay the 2s. 6d. for it. What the chemist did was to pour into the bottle a strong solution of Epsom salts, and add to that a solution of sugar and water and cochineal, and in that way produced a homogeneous solution. Similarly, a good foundryman did not make up a copper-tin alloy directly by melting copper and adding tin to it; he always prepared what he called a white mixture—which was analogous to the chemist's strong solution—and, therefore, he gave it a second melting and obtained a better solution.

Discussing the call in the specification of some firms for the use of virgin metals, MR. MILNER said that his foundry had had to meet orders for very light castings, of not more than 4 or 5 ounces, in a mixture similar to a red bronze, *i.e.*, 85/5/5/5, and the customers had insisted upon the use of virgin metal—electrolytic copper, electrolytic zinc, and so on. The results obtained with the new metals, however, were not so good as those obtained by first melting the metal, running it into ingots, and running the castings from the second melt with an addition of zinc to make up the amount lost by oxidation on the first melt.

XUM

Twice Melting.

The PRESIDENT, discussing the problem of "twice melting," said that, when compounding an alloy, the major portion of which was copper, it was necessary not only that the copper be rendered molten, but it must be superheated. All metals, at high temperatures, have a tendency to absorb gas and to give off that gas during solidification. It was far better that the gas should be given off when the metal was cast in the form of an ingot for remelting than that it should be found in the ultimate casting. Therefore, it was considered better practice to cast first into ingot form and to remelt at a lower temperature for the ultimate casting into shape than to attempt to make the metal and cast direct. The latter method was not, however, impracticable, provided one exercised the greatest care and paid particular attention to relative temperatures.

MR. VICTOR STOBIE said that the President's remarks with regard to gases coming off from the metals on solidification applied to the ferrous as well as to the non-ferrous. If one made a steel by a highly oxidising process without further treating it, one found that, the moment it solidified, carbon monoxide and a complex range of gases came off; roughly in proportion to the severity of oxidation of the melting process. That could be avoided in the main by deoxidising prior to casting. He asked whether the de-gasifying of a non-ferrous metal prior to casting would be less advantageous than a premelting and ingotting of the metal.

The PRESIDENT pointed out that Mr. Stobie had rather jumped to a conclusion. He (the President) had not mentioned oxygen, but had referred to "gases." One could deoxidise an alloy, but there were other gases with which it was not so easy to cope.

MR. A. LOGAN said the general concensus of opinion was that a double melting was better than direct melting, and possibly that was so in the majority of cases, but it was not absolutely necessary.

The PRESIDENT pointed out that that was what he had stated, namely, that castings can be produced satisfactorily without resort to double melting, but only when the necessary precautions are taken.

MR. LOGAN agreed, and said he merely wanted to confirm that statement.

On the motion of the PRESIDENT, seconded by MR. W. CARTLAND, a hearty vote of thanks was accorded Mr. Dews for his Paper.

Proposed Reconstruction of Scotch Motor Concern.

It is proposed to place the Arrol-Johnston and Aster Engineering Company, Limited, into voluntary liquidation with a view to reconstruction or sale. The liquidator of the Aster Engineering Company (1913) has issued a statement of affairs as at March 16, and in his report he announces that negotiations for the disposal of shares in Arrol-Johnston and Aster Engineering Company have failed. The accounts of the liquidator showed that the estimated surplus assets over liabilities, subject to further liquidation expenses, is £87,313. The Aster Engineering Company (1913) was acquired in 1927 by the Arrol-Johnston motor-car manufacturers, when the title was changed to Arrol-Johnston and Aster Engineering Company, Limited. The latter has a capital of £200,000 in 100,000 6 per cent. preference and 100,000 ordinary shares, all of £1.

ACCORDING TO a Berlin report, the Polish railmakers intend to undersell the Irma (International Rail Makers' Association). They will concentrate their efforts in the South American markets, which are now largely supplied by the British and American groups.

Imported Steel Nails.

Application for Marking Order.

An application by the Steel Nail Association for an order making it compulsory that the foreign origin of imported steel nails should be indicated at the time of sale, or exposure for sale, was the subject of inquiry at the Board of Trade offices, Westminster, on Monday, June 24. The inquiry was conducted by the Standing Committee appointed by the Board of Trade, Sir H. Llewellyn Smith presiding. The Iron, Steel, Tinplate and Metal Merchants' Section of the London Chamber of Commerce were also represented (by Mr. H. J. Skelton) at the inquiry, but did not oppose, in as much as they had negotiated previously with the applicant Association and had arrived at an agreed arrangement as to the products to be marked and the methods of marking them.

This agreed arrangement was put before the Committee for its approval. In it the parties asked the Committee to define the articles to be covered by the Order as "cut steel nails." It was asked that the nails should bear the indication of origin at the time of sale or exposure for sale, and not at the time of importation; that, when nails were sold or exposed for sale in kegs, the marks should be applied to the kegs; when sold or exposed for sale in bags, the marks should be applied to the bags or on a metal or linen tally attached securely to each bag; and that the marks should, at the option of the person applying them, be embossed, stencilled or otherwise painted in a distinctive colour, or indelibly stamped or printed. It was asked also that quantities of 14 lbs. or less should not be marked except when sold or exposed for sale in the packages in which they were imported. Some discussion arose as the result of the chairman's inquiry as to why the word "cut" was included in the definition. It was stated on behalf of the applicants that 99 per cent. of the trade is in cut nails, and that the definition was not adopted with a view to excluding any particular types of nail.

Evidence in support of the applicants was given by Mr. J. H. Reynolds (managing director of Messrs. John Reynolds & Sons, Limited). He said that the quantities imported had not been extremely heavy so far, but he thought they were increasing. The manufacturers were alive to the fact that users of nails would buy wire nails if the cut nails they bought were not satisfactory, and it was the desire of the manufacturers to provide nails of good quality in order to keep the cut-nail trade going. He agreed with Mr. Skelton that the holding power of the cut nail was at least 200 per cent. greater, as shown by tests.

The inquiry was concluded.

Continental Steel and Rail Cartels.

The managing committee of the Steel Cartel decided to increase the aggregate quotas for the ensuing quarter by 1,000,000 tons, thus bringing the total for the year to 32,295,000 tons. This decision was reached at the meeting in Paris recently. The question of the renewal of the Cartel after the lapse of the existing agreement on October 31 was discussed, but no understanding was arrived at, although expression was given to the desirability of continuing the organisation. It was resolved to continue the discussion on the matter at the next meeting, which is to be held at the end of September, presumably in Vienna. At the meeting precise proposals for the prolongation of the Cartel were made only by the German group. These aim at a revision of the quotas on the basis of the actual production in recent years and the grant of equal rights for all groups in regard to the export trade. Pending the September meeting the other groups will prepare their proposals for the suggested renewal of the Cartel.

The text of the agreement entered into in London in April between the representatives of the various groups in the International Rail Makers' Association (Irma) was definitely signed at a meeting in Paris recently, the agreement being extended to March 31, 1935. No change was made in sellling prices, although the English and German representatives who were present suggested that the rates for basic steel rails should be raised by 2s. 6d. per ton and those of open-hearth steel by 3s. per ton. Selling prices have now remained without change since last September, basic rails being at £6 10s., open-hearth steel rails at £7 17s. 6d., and fishplates at £8 10s., all f.o.b.

French Ironmasters' Association.

REPORT FOR 1928.

The managing committee of the Comité des Forges de France, of which M. F. de Wendel is president, have issued their annual report for 1928, which was approved at the recent meeting and from which we give the following extracts.

The production of pig-iron during the year under review amounted to 10,097,000 metric tons, as against 9,326,000 in 1927, and that of steel to 9,387,000 tons, as compared with 8,306,000 in the previous year. The monthly rate of output was fairly uniform, passing from 809,000 tons of pig-iron in January to 880,000 tons in December, as compared with a monthly average of 749,000 tons in 1913 within the present frontiers. The number of active blast furnaces rose from 144 on January 1 to 153 at the end of December. In the case of steel ingots and castings, the monthly output increased from 753,000 tons in January to 828,000 tons in December, as compared with a monthly average of 559,000 tons in 1913, also within present territorial boundaries.

Supplies of Coke and Scrap.

After referring to the steps taken for developing the home market, the report deals with the questions of coke and scrap supplies. In the case of coke, the cost of which represents more than one-half of the costs of making pig-iron, the report states that this point has constantly occupied attention. The conferences between the iron industry and the coal industry were continued last year in the most friendly spirit, and have permitted the ironmasters to get coke at a price much more in proportion to the selling prices of iron and steel products than the rates paid in previous years, and at the same time to increase the share of French coke in the consumption of the ironworks. For the rest this tendency was manifested last year in the bringing closer together of the bonds which unite the iron and steel companies with the colliery companies in view of obtaining a closer and steady co-operation.

Concerning the scrap problem, the report states that the development of the basic process in France is due to the abundant resources of phosphoric ores available in the country, but it must not be overlooked that the production of open-hearth steel represents 28 per cent. of the total French steel output, and that the raw material essential for this process in France is scrap. At the present time the scrap requirements are growing in all countries, apart from Belgium and Luxemburg, where the open-hearth process has been but little developed.

Under the circumstances—the report submits—it is not surprising that all the European countries concerned have been induced to take measures to restrict the export of scrap, while at the same time endeavouring to facilitate the supply to their own industries by getting supplies in foreign markets. The measures adopted in France are unfortunately much less strict than those in neighbouring countries, and permit the export, besides the officially permitted tonnage contingent, of considerable quantities of old material declared under an incorrect denomination or resulting from the breaking up of old ships.

Having regard to this situation and in view of the increases in the prices of scrap, which are now largely in excess of the equivalent gold prices in the pre-war period, the Comité des Forges have sought, in agreement with the administration and all parties interested, to arrive at a solution which would ensure the necessary stability for the favourable course of manufacturing, from the standpoint of both the supplies and prices of scrap. In this connection it is urged that the present conditions of world competition do not allow this important factor in the costs of production to be neglected, and to let the resources of the country be exhausted for the benefit of foreign rivals—resources which would rapidly appear insufficient with an increase in the French production of open-hearth steel.

In conclusion, the report deals with, among other matters, the question of railway rates, taxes, social welfare burdens and Customs tariffs.

THE KEIGHLEY GEAR CUTTING COMPANY have purchased the plant, goodwill, stock and records of Messrs. E. Arnold Pochin & Bro., gear manufacturers and cutters, of Trafford Park, Manchester. The services of Mr. Arnold Pochin are being retained.

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Trade Talk.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Glasgow, have received an order from the Bengal-Nagpur Railway Company for 25 locomotive boilers.

THE LILLESHALL COMPANY, LIMITED, have put out of operation the blast furnace they had previously working on the production of forge and foundry pig-iron. This is only a temporary measure.

AS THE RESULT of molten metal falling on Albert Hodgson, an ironfounder employed at the Canal Iron Works of Messrs. J. Parkinson & Sons, Shipley, it is feared that he will lose the sight of an eye.

MR. NEVILLE CHAMBERLAIN, M.P., will preside at the 81st anniversary banquet of the Royal Metal Trades Pension and Benevolent Society, which will be held at the Hotel Victoria, London, W.C.2, on Wednesday, December 4 next.

THE BRITISH INDUSTRIES FAIR, Birmingham, next year will be held from February 17 to 28 at Castle Bromwich. In the prospectus it is stated that the total floor space of the exhibition building (under one continuous roof) is 400,000 sq. ft. It is hoped to make a further extension of 65,000 sq. ft.

WAGES OF BLAST-FURNACE MEN in West Cumberland and North Lancashire rose by 1¾ per cent. to 22½ per cent. above standard as a result of the May and June ascertainments, showing that the average selling price of Bessemer mixed numbers of hematite pig-iron was 70s. per ton, against 68s. 7d. per ton in the months of March and April.

MESSRS. VACCARO BROS. & COMPANY, New Orleans, who are closely identified with the Standard Fruit and Steamship Corporation of America, have placed an order for the construction of a high-class passenger and fruit-carrying boat for the service between Central America and New York with Messrs. Barclay, Curle & Company, Limited, Glasgow.

MESSRS. JOHN G. KINCAID & COMPANY, LIMITED, Greenock, have obtained an important contract to supply machinery for a 10,000-ton oil-tanker, which is to be built at Sunderland, from Messrs. John I. Jacobs & Company, Limited. The machinery will consist of two sets of Diesel engines, capable of developing 3,510 b.h.p., of the single-acting cross-head Harland B. & W. type.

THE POLISH MINISTRY OF COMMERCE has refused to sanction the rise in inland prices asked for by the Polish iron and steel producers. The Ministry has made a thorough investigation of the situation of the industry in Upper Silesia and the Dombrowa district, and found the claim for higher prices fully justified, but inopportune for the time being. The matter is to be reconsidered next August.

THE NATIONAL EXECUTIVE of the Amalgamated Engineering Union, in their recent report, state that returns from the Clyde area show that trade remains very good in the Clyde and South-West Scotland area. Industry is particularly busy in Greenock, Paisley and Dumbarton, but is very slack in Dumfries and Kilmarnock. There has also been a falling-off in engineering employment in Mid-Lanark.

IN THE first report of the Duffield Iron Corporation, Limited, it is intimated that a statement of the position of the company's affairs will be made by the chairman at the annual meeting. The company has, continues the report, secured on lease an iron-ore property and a suitable works site adjacent. A building has been erected to accommodate the plant and machinery, which is now being installed. It is expected that this plant will be tested next month and put into operation in September.

A MEETING OF THE creditors of Messrs. Hall, Lewis & Company, Limited, railway carriage and wagon builders, of Cardiff, was held in London last week, when a resolution in favour of the continuance of the voluntary winding-up was passed. A resolution ratifying the appointment of Sir Gilbert Garnsey as liquidator was also declared carried. A petition for a compulsory winding-up order had already been before the Court, and was adjourned to give the creditors an opportunity of expressing their views on the voluntary proceedings. A meeting of the shareholders on June 26 resolved that the company should be wound up voluntarily.

THE ELECTRIC FURNACE COMPANY, LIMITED, of 17, Victoria Street, London, S.W.1, have recently concluded an agreement with Hirsch, Kupfer und Messingwerke A.G., Eberswalde, Germany, in accordance with which they have the right to the British and French patents, and the use of drawings and information, relating to the various types of electric resistance furnace developed by the latter company. Messrs. Hirsch have probably applied electricity to metal melting, annealing and reheating to a greater extent than any other non-ferrous metal manufacturers. Their furnace equipment includes continuous strip-annealing plant, side-charged tube-annealing furnaces, bright annealing furnaces, and furnaces for reheating ingots, in addition to a large battery of Ajax-Wyatt and Ajax-Northrup furnaces.

IN THE COURSE of a Paper on "Steel Sleepers on Colonial Railways," read by Mr. J. W. Spiller at the summer Convention of the Permanent Way Institute, held in Newcastle, the author stated that the world's consumption of timber was steadily increasing, and sooner or later a shortage must occur. Steel sleepers were used almost exclusively in Nigeria, the Gold Coast, Sierra Leone, Kenya and Uganda, and Tanganyika. Many sleepers laid from 20 to 30 years ago were still doing useful service. One advantage which could be definitely claimed for the steel sleeper was the fact that it could be produced in this country and would displace an imported article. If steel sleepers were used for only one-third of the sleeper requirements of British railways, it would necessitate the manufacture of 100,000 tons of steel every year and the transport of nearly 500,000 tons of raw material, so that a portion of the cost would be directly returned to the railways in the form of freight receipts.

Personal.

MR. W. H. COATES has been elected a director of Imperial Chemical Industries, Limited. Mr. Coates is treasurer to the company.

MR. SUMMERS HUNTER, chairman and managing director of the North Eastern Marine Engineering Company, Limited, of Wallsend, has retired after 49 years' association with the firm.

MR. G. E. ROWLAND, chairman of Agricultural & General Engineers, Limited, who was to have represented general engineering on the Economic Mission to Argentina and Brazil, has been unavoidably compelled to withdraw from the Mission, and the Foreign Office announces that Mr. W. Howard-Williams has accepted an invitation to take his place.

Wills.

RUSSELL, W., metal merchant, Glasgow ...	£11,693
LAIDLAW, J., of Messrs. Watson, Laidlaw & Company, Limited, Glasgow, machinery makers	£76,574
ANDERSON, H., of Cambuslang, a director of the Rivet, Bolt and Nut Company, Limited, and of the North-West Rivet, Bolt and Nut Factory, Limited	£30,072

Contracts Open.

Burnley, July 29.—Six cast-iron purifier-boxes, for the Town Council. Mr. J. H. Clegg, engineer and manager, Gas Offices, Parker Lane, Burnley.

Cairo, September 28.—Machine tools, Diesel and semi-Diesel engines, boilers, etc., for the Prisons Administration, Ministry of the Interior, Cairo. The Department of Overseas Trade. (Reference A.X. 8,245.)

Cairo, September 16.—Steel pipes, sluice valves, hydrants, etc., for the Ministry of the Interior, Municipalities and Local Commissions Section. The Department of Overseas Trade. (Reference A.X. 8,248.)

Dundee, July 27.—620 yds. of 18-in., 3,110 yds. of 24-in., 2,935 yds. of 30-in., concrete-lined spigot and socket cast-iron pipe, and special castings, for the Corporation. Mr. G. Baxter, junr., waterworks engineer and manager.

Johannesburg, August 15.—Cast-steel automatic couplers, for the South African Railways and Harbours. The Department of Overseas Trade. (Reference A.X. 8,177.)

Montevideo, October 31.—Steel rails and accessories, for the Uruguayan State Railways and Tramways. The Department of Overseas Trade. (Reference A.X. 8,220.)

Porto Alegre, August 2.—Ten locomotives, five first-class sleeping coaches, four first-class restaurant coaches, six first-class passenger coaches, six luggage and mail vans, 80 closed goods wagons and 50 gondola wagons, for the Director-General da Viacao Ferrea do Rio Grande do Sul, Porto Alegre. The Department of Overseas Trade.

Wallingford, August 1.—153 tons of 7-in. and 136 tons of 6-in. spigot and socket cast-iron pipes, with five tons of bends and branches, for the Rural District Council. Messrs. Fiddian & Deeley, 13, Church Street, Stourbridge. (Fee £2 2s., returnable.)

Reports and Dividends.

J. Samuel White & Company, Limited.—Net profit, £37,217, reducing the debit balance on profit and loss account to £27,619.

Howard & Bullough, Limited.—The directors have decided not to pay a dividend on the ordinary shares for the first quarter of the current financial year.

Duffield Iron Corporation, Limited.—The accounts show an excess of expenditure over income for the period from February 9, 1928, to March 31 last of £4,366.

David & William Henderson & Company, Limited.—Net loss, £1,098; brought in, £2,949; transferred from reserves, £20,000; depreciation, £3,710; carried forward after payment of preference dividend, £3,141.

Charles Roberts & Company (1927), Limited.—Profit for nine months ended March 31 last, £40,743; depreciation, £31,501; brought in, £10,349; income-tax, £3,500; interim dividend on 6½ per cent. preference shares, £8,125; carried forward, £7,966.

Bengal Iron Company, Limited.—Profit (including £225,646 due from the Indian Iron and Steel Company, Limited), £331,074; brought in, £16,496; depreciation and colliery sinking fund, £79,540; debenture interest, £64,787; debenture sinking fund, £25,212; written off debenture discount account, £4,550; preference dividend, £37,500; dividend on the ordinary shares of 5 per cent., £79,719; carried forward, £56,260.

New Companies.

Lewis & Goodman, Limited, 54, Hobson Street, Oldham.—Capital £3,000. Brassfounders, etc. Directors: J. H. Lewis, T. Lewis and E. Lewis.

Frank White, Limited, 41, North John Street, Liverpool.—Capital £5,000 in £1 shares. Engineers, iron and brass founders, etc. Directors: F. White (chairman and managing director) and Mrs. M. White.

Magnetic and Electrical Alloys, Limited, Sunnyside Road Works, Ilford.—Capital £1,000. Metallurgical engineers, etc. Directors: J. A. Holden (chairman and managing director), A. A. Asplin and A. Shuttleworth.

Applications for Trade Marks.

The following applications to register trade marks are extracted from the "Trade Marks Journal":—

"CLUSTER SIX."—Metals. Emery Brothers, Limited, Lichfield Road, Aston, Birmingham.

"ALCLAD."—Metals. Aluminium Company of America, c/o White, Langner, Stevens, Parry & Rollinson, 88, Chancery Lane, London, W.C.2.

Obituary.

MR. W. M. STEPHENSON, joint managing director of Messrs. Ord & Maddison, Limited, engineers and ironfounders, of Darlington, died on Friday, July 12, aged 69.

MR. ROBERT WILLIAM KENNARD, D.L., J.P., late chairman of the Falkirk Iron Company, Limited, has died at his residence, North Leigh, Bradford-on-Avon. Mr. Kennard was the son of the late Mr. Howard John Kennard, one of the original partners of the firm, and was the first chairman of the Falkirk Iron Company, Limited, a position he recently relinquished owing to failing health. Mr. Kennard was in his 72nd year and was a High Sheriff of the County of Monmouth. His only surviving son, Captain H. J. Kennard, R.N., is the present managing director of the Falkirk Iron Company, Limited.

MR. T. V. MILES, J.P., a director of Messrs. Newton Chambers & Company, Limited, and manager of the firm's Thorncliffe Ironworks, died suddenly on July 12, at Aarhus, Denmark. Mr. Miles began his career in the iron trade at Tredegar. Subsequently he went to Glasgow and later was for five years with the Staveley Coal and Iron Company, Limited. Acting on behalf of several important firms he investigated iron and steel foundry methods in the United States and on the Continent of Europe. His next appointment, in 1900, was with the Holwell Iron Company, Limited, Leicestershire. In 1908 he went to the Thorncliffe Works of Messrs. Newton Chambers & Company, Limited, as general manager. He initiated and carried out a re-planning of the works, and was subsequently elected a director of the company.

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If the proposition presents any difficulty, send for us to talk it over and we will undertake to meet your reasonable views. If you use foreign sand, you can't legitimately complain of engineers using foreign castings.

We don't sell foreign castings and deprive you of work. We support British Institutions and trade and technical associations. We live here and pay British rates and taxes. We help to buy your output.

We don't ask for orders for 500-ton lots (payment against B/L), we sell in truck loads and wait for our money—sometimes three or four months (sometimes we never get it at all). We are always here at the end of a wire for advice, help or support. If you receive from us any goods you don't like—send them back.

We give prompt delivery of Yorkshire Sand and every ton lot of it you buy finds work for Englishmen and Scotsmen and helps to improve your own business by circulating more money in the country, and reducing the amount sent abroad for needless foreign purchases.—Think it over and you will see we are right.

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—The mid-summer period is generally marked by quiet intervals in the Cleveland iron market, and on this occasion there is rather less activity observable than usual owing, it must be admitted, more to scarcity of supplies than to any weakening of demand. The chief factor, however, in the present difficult position of the Tees-side ironmasters is that of fuel supplies, most of the Durham coke makers having sold the whole of their output for weeks ahead, and large orders for coke are being refused. Moreover, as is usual in times of scarcity, prices are advancing rapidly, and it is by no means certain that the peak has yet been reached. It is true that most of the ironworks have covered their present needs, but they will have difficulty in relighting more blast furnaces until more coke is available, and, moreover, the prices quoted are high. In the existing circumstances there is ample justification for the rise in the price of pig-iron, and for small prompt lots merchants, who are the only sellers, have no difficulty in realising current quotations, as follow:—No. 1 Cleveland foundry iron, 75s. per ton; No. 3 G.M.B., 72s. 6d.; No. 4 foundry, 71s. 6d.; No. 4 forge, 71s. per ton.

The demand for East Coast hematite continues active, both on home and export account, and more local furnaces are going into blast immediately. Prices also have a firmer tendency, and, while concessions might be made on export orders and also on big parcels for home delivery, 75s. per ton is now the recognised market figure for East Coast mixed numbers, with 75s. 6d. for No. 1 quality. On the North-West Coast also prices are firm, Bessemer mixed numbers being quoted 75s. per ton at works.

LANCASHIRE.—Although affected to some extent by local holiday influences, markets for foundry pig in this area report fairly active conditions, deliveries to consumers being usually steadily maintained, with prices firm at about previous rates, as follow:—Derbyshire No. 3, 72s.; Staffordshire, 73s.; and Scottish brands, 91s. to 92s., all delivered equal Manchester.

THE MIDLANDS.—At Birmingham this week few transactions in foundry pig of any magnitude have been reported, most of the heavy consumers being well covered by forward contracts. As a general rule, the furnaces are asking 2s. 6d. premium over zone figures for new purchases, the minimum controlled figures being 73s. 6d. for Derbyshire No. 3, 74s. 6d. for Staffordshire No. 3, and 70s. for Northants No. 3, delivered local stations.

SCOTLAND.—Following the cessation of work for the annual holidays last week, business in the Scottish markets has been very restricted. Makers, however, firmly adhere to the official minimum of 76s. per ton f.o.t. furnaces for No. 3 Scotch foundry pig-iron, and, despite the poor demand, there is no immediate prospect of this figure being shaded; in fact, the chances are that further advances will take place, as the producers are not at all satisfied with the price they are getting.

Finished Iron.

In the Black Country the demand for Staffordshire marked bars is on a considerably better scale, but the price remains firmly at £12 at makers' works. The recent improvement in the call for crown bars is maintained, and a good Staffordshire make would be at between £10 and £10 5s. per ton. Other crown bars are offered from this and other districts at prices between £9 10s. and £10 per ton. Little support is possible for local makes of nut and bolt iron, as the price cannot be compared with that of the Continental iron, which is coming through in considerable quantities. The Continental makers are quoting £7 2s. 6d. to £7 5s. delivered Darlaston district, against £9 to £9 5s. for the Staffordshire product.

Steel.

Conditions generally in markets for semi-products remain quiet and uneventful, consumption being on a lower scale owing to the usual effects of the summer months. In addition, the continued weakness in prices quoted by the Continental makers is resulting in more orders going abroad. On the whole, however, the British makers are obtaining the larger share of the orders for semis emanating from home consumers. The weaker tendency in this market is most noticeable with regard to sheet bars, which are suffering as a natural consequence of the depression in the sheet trade. The tinplate market is quiet, but steady, with quotations ruling as follow:—Coke tinplates, 18s. 1½d. to 18s. 6d. basis for approved specifications, net cash, f.o.b. Welsh ports.

Scrap.

Only a moderate volume of business is reported passing in the chief markets for scrap metals, and in Scotland very few transactions are recorded on account of the prevailing holidays. At Middlesbrough cast-iron scrap is still firm, and no depreciation is anticipated while the pig-iron market is in its present condition. From 70s. to 72s. 6d. per ton is still offered for machinery scrap in cupola sizes, and 60s. for light cast-iron scrap. In the Midlands the rising prices of pig-iron have not yet influenced the market for cast-iron scrap, and 66s. is regarded as a relatively low figure for ordinary heavy cast iron, with a premium of 2s. 6d. per ton for machinery quality.

Metals.

Copper.—Movements in warrant copper of late disclose little animation on the part of buyers, with values distinctly weaker and tending to still lower levels. The recently enforced curtailment of production is already reflected in the returns of the production of blister copper, which show a decrease of about 10,000 tons, while the stocks of blister copper have decreased by more than that quantity. With regard to the future, the outlook is uncertain, as the period must now be drawing to a close for which not only were consumers supposed to be well covered, but producers also fully sold.

Closing quotations are:—

Cash.—Thursday, £71 to £71 2s. 6d.; Friday, £72 15s. to £72 17s. 6d.; Monday, £72 15s. to £72 17s. 6d.; Tuesday, £72 2s. 6d. to £72 5s.; Wednesday, £72 to £72 2s. 6d.

Three Months.—Thursday, £71 16s. 3d. to £71 17s. 6d.; Friday, £73 7s. 6d. to £73 10s.; Monday, £73 7s. 6d. to £73 10s.; Tuesday, £72 17s. 6d. to £73; Wednesday, £72 17s. 6d. to £73.

Tin.—Following the inauguration of the recently-formed Tin Producers' Association, as announced in these columns in last week's issue, markets for standard metal have steadily developed a firmer tendency in values, and the position now seems assured for some time in advance. At all events, the market is now subject to optimistic influences, that afford some assurance of continued stability, as denoted by an increasing firmness in quotations both at home and abroad.

Official closing prices:—

Cash.—Thursday, £210 15s. to £211; Friday, £214 to £214 5s.; Monday, £214 15s. to £215; Tuesday, £212 10s. to £212 15s.; Wednesday, £214 15s. to £215.

Three Months.—Thursday, £214 to £214 5s.; Friday, £217 5s. to £217 10s.; Monday, £218 5s. to £218 10s.; Tuesday, £216 5s. to £216 10s.; Wednesday, £218 15s. to £219.

Spelter.—The market for ordinary spelter has again developed weakness, mainly on account of the poor Continental demand, and a revival of activity is not anticipated until this shows some improvement.

Daily quotations are:—

Ordinary. — Thursday, £25 7s. 6d.; Friday, £25 7s. 6d.; Monday, £25 6s. 3d.; Tuesday, £25 5s.; Wednesday, £25 1s. 3d.

Lead.—Soft foreign pig at the moment is at a price which is relatively cheap, and there are indications which point to a revival in the demand in the near future, followed by a consequent recovery of values.

Prices have been:—

Soft Foreign Prompt.—Thursday, £22 11s. 3d.; Friday, £22 15s.; Monday, £22 16s. 3d.; Tuesday, £22 12s. 6d.; Wednesday, £22 8s. 9d.

Students' Corner

Q.—What is an ore?

A.—An ore is a substance containing a metal in its natural state, chiefly as sulphide, oxide or carbonate, and sometimes as a sulphate, phosphate or silicate. Magnetite or magnetic iron ore is the richest ore of iron. When it is pure it contains 72.41 per cent. of iron.

Q.—Are there many kinds of ores from which iron is smelted?

A.—The different kinds of ores are too numerous to dwell upon; some are richer in iron, and are more easily reduced in the blast furnace than others. Ores consist chiefly of oxides and carbonates mixed with varying amounts of limestone, silica, clay, and often with small quantities of phosphates and sulphides. Native iron occurs in meteoric masses.

The analysis of a Cumberland ore is given as follows:—peroxide of iron, 85.00; protoxide of manganese, 0.21; alumina, 0.76; lime, 1.47; silica, 6.03; carbonic acid, 1.35; phosphoric acid, 0.02; and water, 4.80 per cent. The metallic iron present is 59.50 per cent. The above ore produces a hematite iron—that is, an iron with a low phosphorus content. Cleveland ironstone produces an iron high in phosphorus. Ores vary in colour. Spanish ores are brown, red and purple; Swedish ores are of different colours and lustre, and are very rich in iron, often containing about 62 per cent. Some of the ores mined in the United Kingdom yield a very low percentage of iron.

Q.—How are the ores first prepared before smelting?

A.—With Cleveland ironstone it is usual to roast or calcine the stone in a kiln. A rail truck is inclined above the kiln, the wagon doors at the bottom are released, and the ironstone drops directly into the kiln. Limestone and coal is charged in a similar manner.

Q.—What is the coal: ore ratio?

A.—One cwt. of coal is allowed for each ton of ore roasted.

Q.—What would be the temperature in the kiln?

A.—The temperature maintained in the kiln is about 750 deg. C.

Q.—How long is the ore required to roast?

A.—The process of calcination takes 40 hours during which time the limestone is reduced to lime.

Q.—How is the ore changed by calcining?

A.—Before calcination the ore was in the form of ferrous oxide, after calcination it becomes ferric oxide.

Q.—How is that change brought about?

A.—By the sulphur, water, volatile matter and carbonic acid being driven off from both the ore and limestone. The raw ore before calcination contains about 28 per cent. of iron (ferrous); after calcination the percentage of iron in the ore is increased to about 40 per cent. (ferric).

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¶ We are specialists.

¶ We are by far the largest makers of moulding boxes.

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¶ We have some thirty different standard designs of boxes from which to choose.

¶ We have the requisite up-to-date plant and equipment for manufacturing moulding boxes on the most economical lines.

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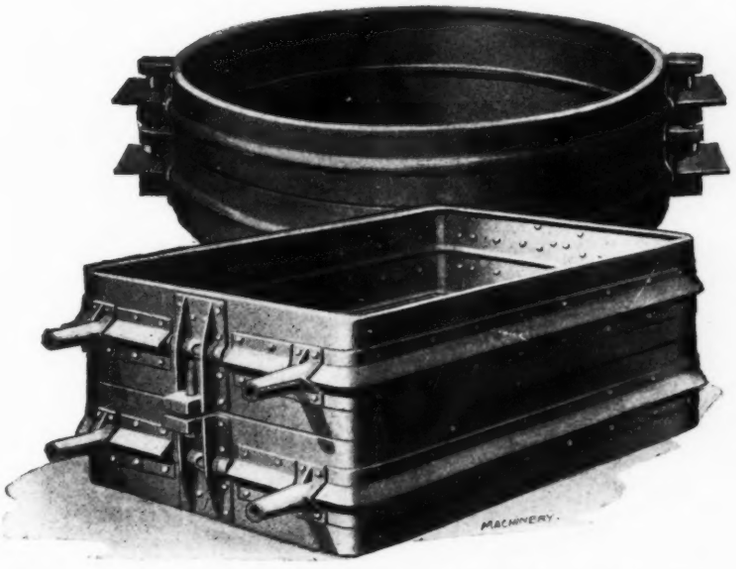
IF STERLING BOXES CANNOT HELP YOU WE WILL TELL YOU SO



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WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	72	0	0
Three months	72	17	6
Electrolytic	84	0	0
Tough	75	0	0
Best selected	75	5	0
Sheets	110	0	0
India	95	0	0
Wire bars	84	10	0
Do. Aug.	84	10	0
Do. Sept.	84	10	0
Ingot bars	84	10	0
H.C. wire rods	86	15	0
Off. av. cash, June	74	7	9
Do. 3 mths., June	73	19	3½
Do., Sttlmnt., June	74	8	0
Do., Electro, June	84	7	0
Do., B.S., June	77	8	1½
Aver. spot price, copper, June	74	7	9
Do. wire bars, June	84	13	9
Solid drawn tubes			15d.
Brazed tubes			15d.
Wire			12½d.

BRASS.

Solid drawn tubes	12½d.
Brazed tubes	14½d.
Rods, drawn	12½d.
Rods, extd. or rlld.	8d.
Sheets to 10 w.g.	11½d.
Wire	11½d.
Rolled metal	10½d.
Yellow metal rods	8d.
Do. 4 × 4 Squares	8½d.
Do. 4 × 3 Sheets	9d.

TIN.

	£	s.	d.
Standard cash	214	15	0
Three months	218	15	0
English	215	10	0
Bars	214	15	0
Straits	216	5	0
Australian	214	15	0
Eastern	220	10	0
Banca	Nominal		
Off. av. cash, June	200	5	9½
Do., 3 mths., June	203	9	6
Do., Sttlmt., June	200	5	4½
Aver. spot, June	200	5	9½

SPELTER.

	£	s.	d.
Ordinary	25	1	3
Remelted	23	0	0
Hard	21	0	0
Electro 99.9	27	5	0
English	25	12	6
India	22	0	0
Zinc dust (Nom.)	34	10	0
Zinc ashes	8	15	0
Off. aver., June	26	2	0
Aver., spot, June	26	4	3½

LEAD.

	£	s.	d.
Soft foreign ppt.	22	8	9
English	24	0	0
Off. average, June	23	12	11½
Average spot, June	23	13	10½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	34	10	0
Do. V.M. ex-whf.	32	12	6
Rods	40	0	0
Boiler plates	30	10	0
Battery plates	31	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	50	5	0
Chinese	31	5	0
Crude	Nominal		

QUICKSILVER.

	£	s.	d.
Quicksilver	22	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	7	15	0
45/50%	12	0	0
75%	19	10	0
Ferro-vanadium— 35/50%	12/10 lb. Va.		
Ferro-molybdenum— 70/75% c. free	4/- lb. Mo.		
Ferro-titanium— 23/25% carbonless	11d. lb.		
Ferro-phosphorus, 20/25%	£16	0	0
Ferro-tungsten— 80/85%, c. fr.	3/3½ lb.		
Tungsten metal powder— 98/99%	3/6½ lb.		
Ferro-chrome— 2/4% car.	£32	10	0
4/6% car.	£23	15	0
6/8% car.	£23	0	0
8/10% car.	£22	15	0
Ferro-chrome— Max. 2% car.	£33	15	0
Max. 1% car.	£37	12	6
Max. 0·70% car.	£41	12	6
70%, carbonless	1/2 lb.		
Nickel—99% cubes, or pellets	£175	0	0
Ferro-cobalt	9/4 lb.		
Aluminium 98/99%	£95	0	0
Metallic chromium— 96/98%	2/6 lb.		
Ferro-manganese (net)— 76/80% loose	£13	15	0
76/80% packed	£14	15	0
76/80%, export	£14	10	0
Metallic manganese— 94/96%, carbonless	1/6 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 0
Finshed bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras— Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{1}{16}$ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.
Bars cut to length, 10% extra	

SCRAP.

	£	s.	d.		£	s.	d.
South Wales— Heavy steel	3	17	0	to	3	18	0
Bundled steel and shrngs.	3	12	6	to	3	16	0
Mixed iron and steel	3	10	0	to	3	12	6
Heavy cast iron					3	2	6
Good machinery for foundries					3	7	6
Cleveland— Heavy steel					3	5	0
Steel turnings					2	17	6
Cast iron borings					2	17	6
Heavy forge					3	17	6
W.I. piling scrap					3	12	6
Cast-iron scrap	3	6	0	to	3	8	6
Lancashire— Cast-iron scrap	3	0	0	to	3	10	0
Hvy. wrought					3	12	6
Steel turnings					2	17	6
Scotland— Heavy steel					3	15	6
Cast-iron borings					2	14	6
Wrought-iron piling					3	13	0
Heavy machinery					3	10	0

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	62	0	0
Brass	41	0	0
Lead (less usual draft)	20	0	0
Tea lead	16	10	0
Zinc	17	0	0
New aluminium cuttings	68	0	0
Braziery copper	54	0	0
Gunmetal	54	0	0
Hollow pewter	150	0	0
Shaped black pewter	106	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast— Foundry No. 1	75/-
Foundry No. 3	72/6
Foundry No. 4	71/6
Forge No. 4	71/-
Hematite No. 1	75/6
Hematite M/Nos.	75/-
N.W. Coast— Hem. M/Nos. d/d Glas.	86/-
,, d/d Birm.	92/-
Midlands— Staffs. common*	—
,, No. 4 forge*	70/6
,, No. 3 fdry*	74/6
Shrops. basic	—
,, Cold blast, ord.	—
,, ,, roll iron	—
Northants forge*	66/-
,, fdry. No. 3*	70/-
Derbyshire forge*	69/6
,, fdry. No. 3*	73/6
,, basic*	—
* d/d Black Country dist.	
Scotland— Foundry No. 1	78/6
,, No. 3	76/-
Hem. M/Nos.	80/-
Sheffield (d/d district)— Derby forge	64/6
,, fdry. No. 3	68/6
Lincs. forge	—
,, fdry. No. 3	72/6
E.C. hematite	86/-
W.C. hematite	87/6
Lincs. (at furnaces)— Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)— Derby forge	—
,, fdry. No. 3	72/-
Northants foundry No. 3	—
Dalzell, No 3 (special)	102/6 to 105/-
Summerlee, No. 3	92/-
Glengarnock, No. 3	—
Gartsherrie, No. 3	92/-
Monkland, No. 3	92/-
Shotts, No. 3	92/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.		£	s.	d.
Iron— Bars (cr.) nom.					10	15	0
Nut and bolt iron	9	0	0	to	9	5	0
Hoops	11	0	0	to	11	10	0
Marked bars (Staffs.) f.o.t.					12	0	0
Gas strip	11	0	0	to	11	10	0
Bolts and nuts, ¾ in. × 4 in.					15	5	0
Steel— Ship plates	8	12	6	to	8	17	6
Boiler plts.					10	10	0
Chequer plts.					10	12	6
Angles					8	2	6
Tees					9	2	6
Joists					8	2	6
Rounds and squares, 3 in. to 5½ in.					9	2	6
Rounds under 3 in. to ¾ in. (Untested)					8	0	0
					and upwards		
Flats, over 5 in. wide and up					8	7	6
Flats, 5 in. to 1½ in.					7	17	6
Rails, heavy					8	10	0
Fishplates					12	10	0
Hoops (Staffs.)	10	0	0	to	10	10	0
Black sheets, 24g.	10	5	0	to	10	10	0
Galv.cor.shts., 24g.	13	2	6	to	13	10	0
Galv. fencing wire 8g. plain					12	0	0
Billets, soft	6	7	6	to	6	17	6
Billets, hard	7	10	0	to	8	2	6
Sheet bars	6	5	0	to	6	10	0
Tin bars	6	5	0	to	6	10	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6½
Rods	1/5
Tubes	1/9½
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled— To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4½ to 1/10½
To 15 in. wide	1/4½ to 1/10½
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round— 3/0 to 10 G.	1/7½ to 2/2½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bessemer billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.95
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.60
Sheets, blue an'l'd, No. 13	2.35
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.30
Tinplates, 100 lb. box	$5.35

COKE (at ovens).

Welsh foundry	24/- to 27/6
,, furnace	21/- to 24/-
Durham and North. foundry	18/6 to 20/6
,, furnace	19/-
Midlands, foundry	—
,, furnace	19/- and up

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box	18/3
,,	28×20 ,,	36/6
,,	20×10 ,,	26/3
,,	18¾×14 ,,	18/9
C.W.	20×14 ,,	15/3
,,	28×20 ,,	33/6
,,	20×10 ,,	21/3
,,	18¾×14 ,,	16/-
Terneplates	28×20	33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0	to	£7	10	0
Bars, hammered, basis	£17	10	0	to	£18	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	15	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£32	0	0	to	£33	0	0
Faggot steel	£20	0	0	to	£24	0	0
Bars and rods, dead soft, steel	£10	0	0	to	£14	0	0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½%	50%
Water	63½%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
July 18		71	0	0	inc.	8/9
„ 19		72	15	0	„	35/-
„ 22		72	15	0	No	change
„ 23		72	2	6	dec.	12/6
„ 24		72	0	0	„	2/6

Electrolytic Copper.

		£	s.	d.			
July 18		84	0	0	No	change	
„ 19		84	0	0	„	„	
„ 22		84	0	0	„	„	
„ 23		84	0	0	„	„	
„ 24		84	0	0	„	„	

Standard Tin (cash).

		£	s.	d.			
July 18		210	15	0	dec.	70/-	
„ 19		214	0	0	inc.	65/-	
„ 22		214	15	0	„	15/-	
„ 23		212	10	0	dec.	45/-	
„ 24		214	15	0	inc.	45/-	

Tin (English ingots).

		£	s.	d.			
July 18		211	0	0	dec.	80/-	
„ 19		214	5	0	inc.	65/-	
„ 22		215	5	0	„	20/-	
„ 23		212	15	0	dec.	50/-	
„ 24		215	10	0	inc.	55/-	

Zinc Sheets (English).

		£	s.	d.			
July 18		34	10	0	No	change	
„ 19		34	10	0	„	„	
„ 22		34	10	0	„	„	
„ 23		34	10	0	„	„	
„ 24		34	10	0	„	„	

Spelter (ordinary).

		£	s.	d.			
July 18		25	7	6	inc.	5/-	
„ 19		25	7	6	No	change	
„ 22		25	6	3	dec.	1/3	
„ 23		25	5	0	„	1/3	
„ 24		25	1	3	dec.	3/9	

Lead (English).

		£	s.	d.			
July 18		24	0	0	No	change	
„ 19		24	0	0	„	„	
„ 22		24	5	0	inc.	5/-	
„ 23		24	0	0	dec.	5/-	
„ 24		24	0	0	No	change	

AVERAGE MONTHLY PRICES OF STEEL BOILER PLATES IN ENGLAND.

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1895	5 15 0	5 15 0	5 12 6	5 12 6	5 15 0	5 17 6	5 15 0	5 17 6	6 0 0	6 0 0	6 2 6	6 0 0	5 16 10½
1896	6 0 0	6 0 0	6 2 6	6 2 6	6 2 6	6 0 0	6 0 0	6 0 0	6 0 0	6 2 6	6 10 0	6 10 0	6 2 6
1897	6 10 0	6 10 0	6 10 0	6 7 6	6 2 6	6 2 6	6 5 0	6 0 0	6 0 0	6 0 0	6 7 6	6 10 0	6 5 5
1898	6 10 0	6 8 9	6 8 9	6 10 0	6 15 0	6 18 9	6 17 6	6 17 6	7 2 6	6 15 0	7 0 0	7 5 0	6 15 8½
1899	7 5 0	8 0 0	8 2 6	8 2 6	8 5 0	8 5 0	8 12 6	8 12 6	8 15 0	8 15 0	9 2 6	9 5 0	8 17 8½
1900	9 5 0	9 5 0	9 7 6	9 10 0	9 12 6	10 5 0	10 5 0	10 5 0	10 5 0	10 0 0	9 15 0	9 15 0	9 15 10
1901	9 5 0	9 5 0	8 15 0	8 10 0	8 10 0	7 10 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 3 11
1902	7 7 6	7 0 0	7 12 6	7 12 6	7 12 6	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 9 7
1903	7 10 0	7 10 0	7 15 0	7 5 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	6 17 6	7 3 11½
1904	6 12 6	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 11½
1905	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 10 0	7 5 0	8 0 0	8 0 0	7 1 3
1906	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 10 0	8 0 10
1907	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 0 0	8 0 0	8 8 4
1908	7 10 0	7 10 0	7 10 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 3 9
1909	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 15 0	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 9
1910	7 0 0	7 0 0	7 1 3	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 10 0	7 10 0	7 10 0	7 5 1
1911	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 14 0	7 10 4
1912	7 18 9	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 15 0	8 16 3	9 0 0	9 2 0	9 5 0	8 11 2½
1913	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	8 19 0	8 15 0	8 5 0	7 15 0	7 15 0	8 17 0
1914	7 15 0	7 15 0	7 15 0	7 13 9	7 10 6	7 5 0	7 0 0	8 0 0	8 2 6	8 5 0	8 5 0	8 5 0	7 15 11½
1915	8 14 0	9 10 0	9 17 6	10 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 4 0	12 0 0	13 0 0	10 15 5½
1916	13 0 0	13 0 0	13 0 0	12 15 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 12 11
1917	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1918	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1919	13 0 0	15 0 0	15 0 0	15 0 0	19 5 0	19 17 6	21 0 0	21 10 0	21 10 0	21 10 0	21 15 0	23 10 0	18 9 9
1920	26 0 0	28 0 0	28 5 0	28 10 0	29 5 0	30 0 0	30 0 0	30 0 0	30 10 0	31 0 0	31 0 0	31 0 0	29 9 2
1921	30 5 0	29 0 0	25 0 0	25 0 0	23 0 0	21 0 0	20 10 0	19 0 0	17 10 0	16 0 0	14 16 0	22 1 9
1922	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	13 1 8	13 10 0	12 15 0	12 10 0	12 10 0	12 10 0	12 6 0	13 10 9
1923	12 8 9	13 6 0	14 0 0	14 0 0	14 0 0	14 0 0	13 12 6	13 0 0	13 0 0	13 0 0	13 0 0	13 10 0	13 9 1½
1924	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	14 0 0	14 0 0	13 11 0	13 5 0	13 5 0	13 10 11
1925	13 5 0	13 5 0	13 5 0	13 1 0	12 15 0	12 15 0	12 15 0	12 15 0	12 7 6	11 14 0	11 10 0	11 10 0	12 11 5½
1926	11 10 0	11 10 0	11 10 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 6 3
1927	11 5 0	11 5 0	11 5 0	11 5 0	11 2 6	11 0 0	11 0 0	11 0 0	10 16 0	10 10 0	10 10 0	10 10 0	10 19 0½
1928	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0
1929	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	—	—	—	—	—	—	—

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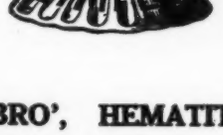
PIG  IRON

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